



The Canadian Precipitation Analysis (CaPA): A seamless precipitation analysis for the Great Lakes (and elsewhere in North America)

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**Recherche en prévision numérique
environnementale**

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Environment Canada**

**20th US - Canada Great Lakes Operational Meteorology Workshop
Chicago, 14 – 16 mars 2012**

Outline

Focus of this presentation

- CaPA objectives, methodology and operational configuration
- Web sites for product dissemination
- Comparison of CaPA with other products (MPE, CPC, USACE)
- Impact of overlake evaporation parameterization on CaPA
- Work in progress

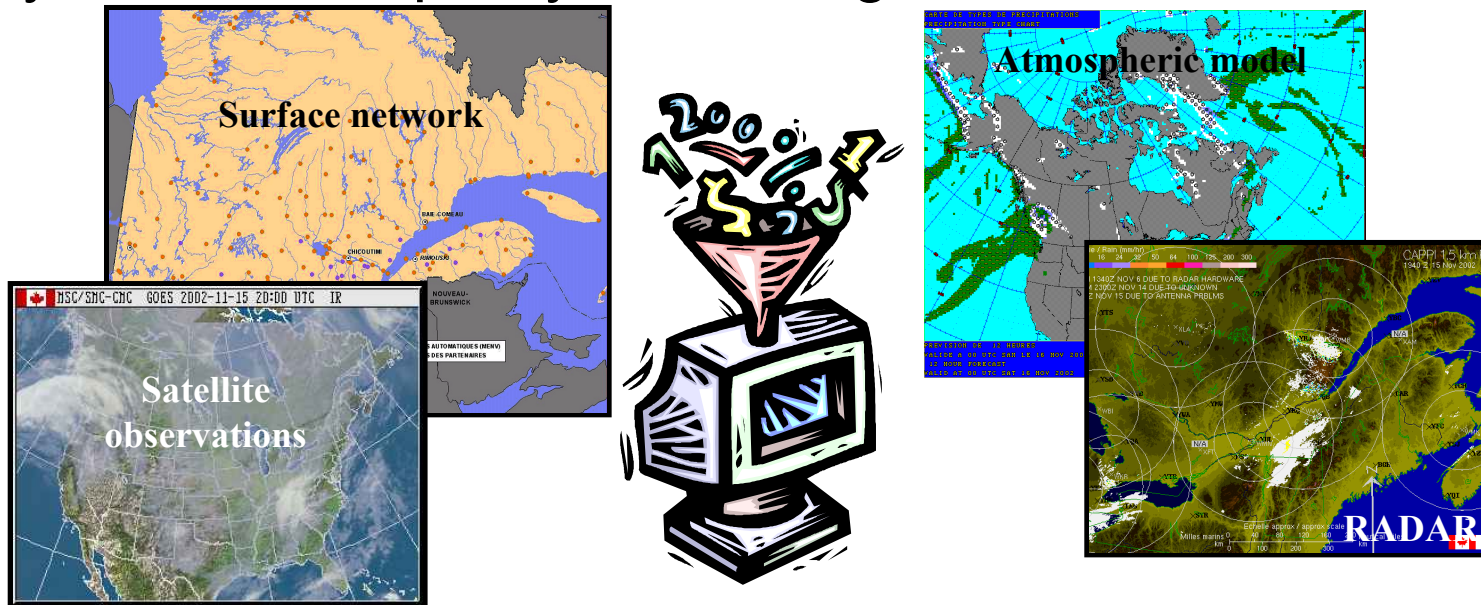
Items left out for lack of time (feel free to ask questions)

- Assimilation of solid precipitation observations
- Objective scores obtained using cross-validation procedure



CaPA objectives and methodology

- Near real-time precipitation estimation
- Merge different sources of information on precipitation
- Use background field from the GEM NWP model due to low network density in most of Canada
- Optimal interpolation technique (aka residual kriging)
- Fully automated quality control algorithm



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CaPA operational configuration

- Assimilates only gauges
 - radar and satellite assimilated in experimental version
- Background field: GEM RDPS 15 km, 6h-12h lead time
- 6h accumulations valid at 00, 06, 12 and 18 UTC
- 24h accumulation valid at 12 UTC
- Confidence index provided (based on kriging variance)



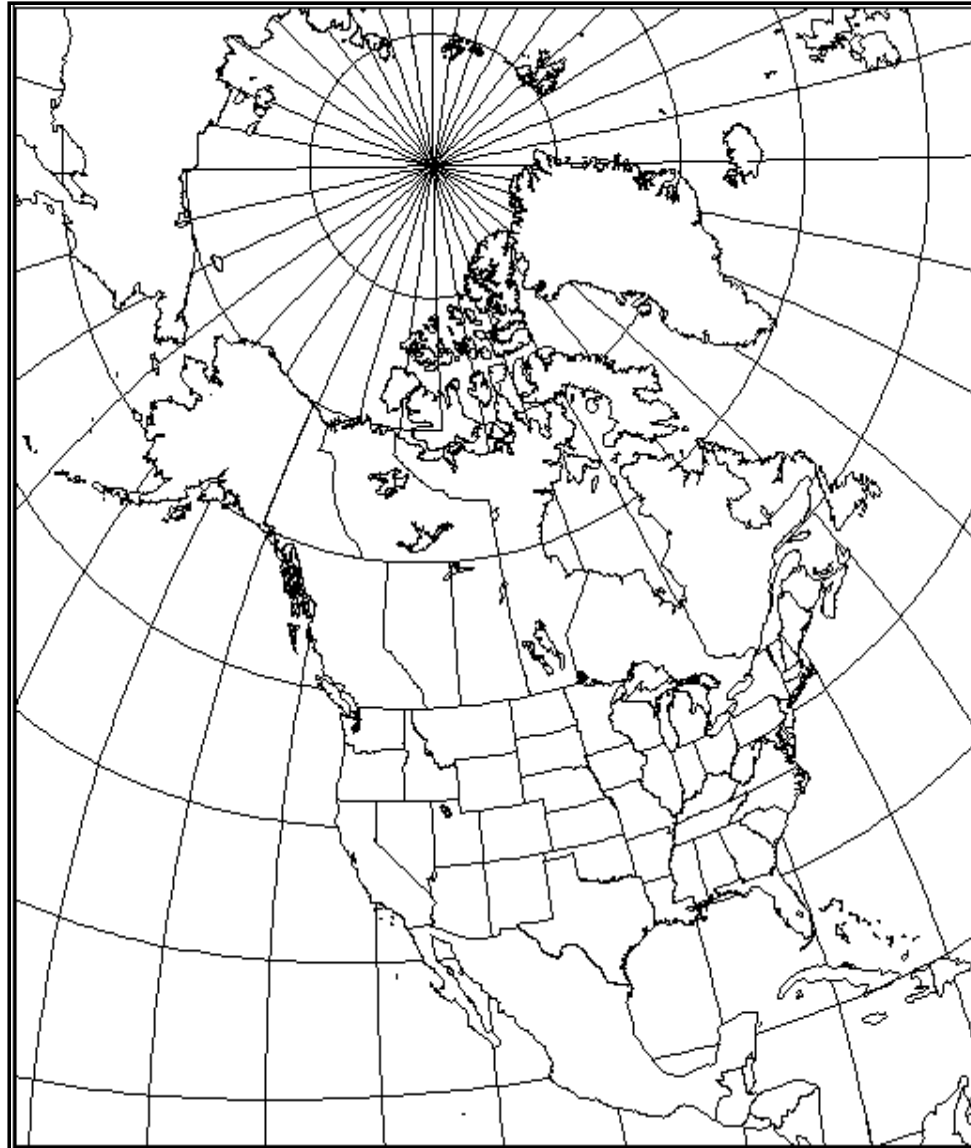
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Canada

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Canada

CaPA domain

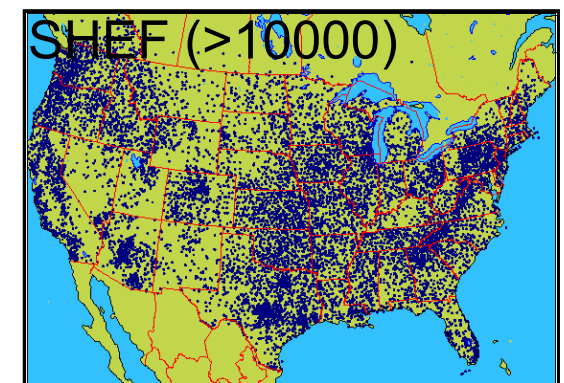
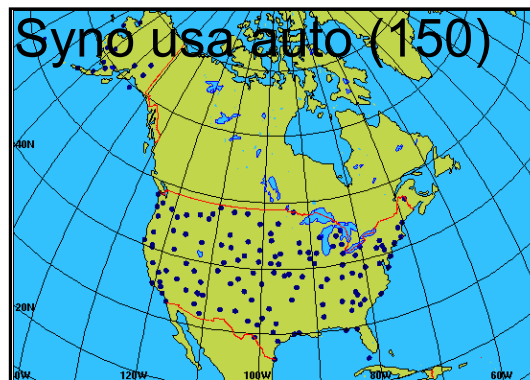
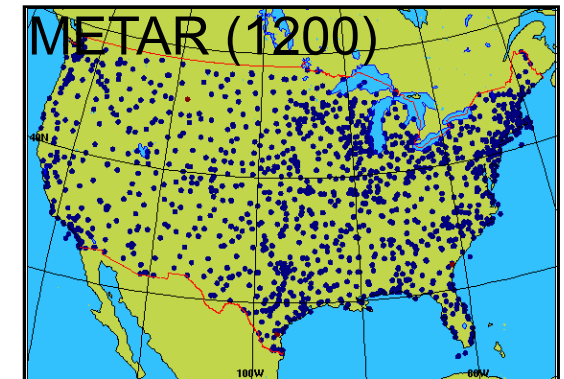
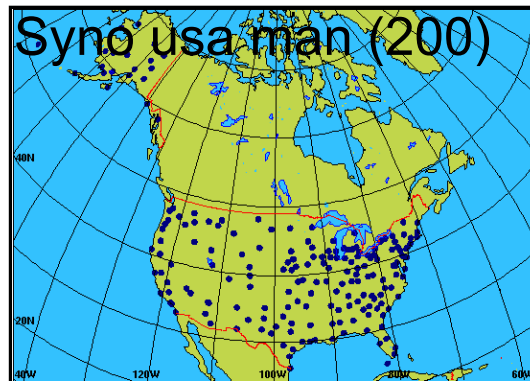
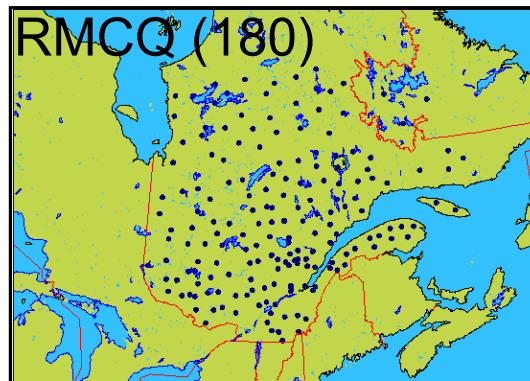
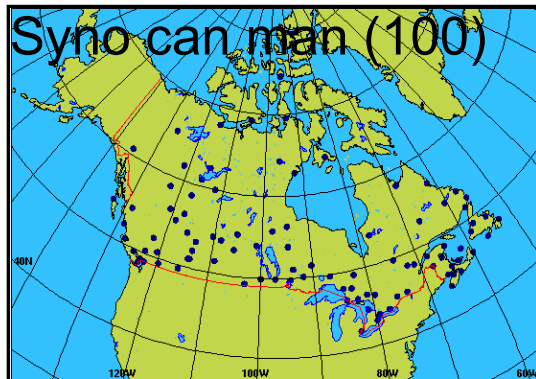


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Surface networks assimilated



(24h analysis only)

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Operational website

<http://www.weather.gc.ca/analysis/>



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[Home](#) > [Analyses and Modelling](#) >

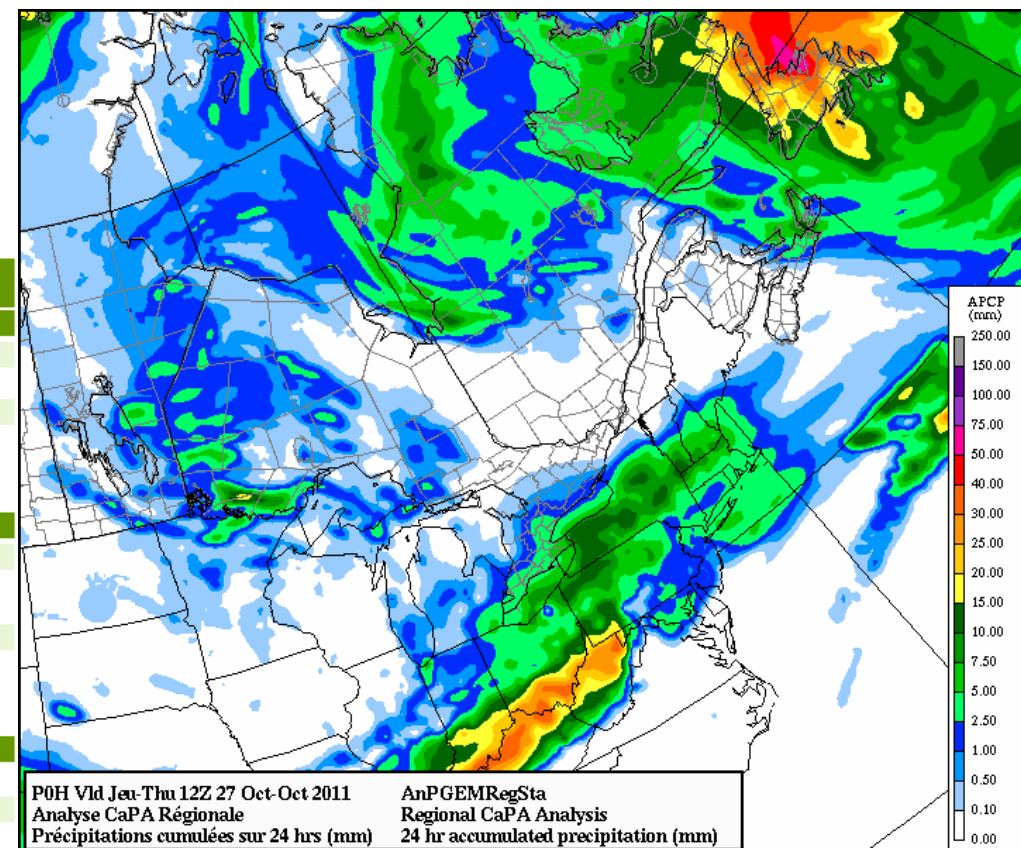
[Warnings](#)
[Current Conditions & Forecasts](#)
[Radar & Satellite](#) +
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[Site Map](#)

Operational Analysis Charts

Surface Analysis: MSLP				
Hr	Preliminary (Canadian coverage)		Complete (Northern Hemispheric coverage)	
	2640x2100	1320x1050	1791x1531	895X765
00z	200k	115k	165k	90k
06z	200k	110k	165k	90k
12z	200k	110k	165k	90k
18z	200k	110k	165k	90k

Surface Analysis : Snow, Ice, SST		
	1213x894	2425x1787
Snow Depth	90k	170k
Sea Surface Temperature	90k	170k
Sea Ice Cover	90k	170k

Surface Analysis: ACP			
Regional Deterministic Precipitation Analysis (RDPA) ⁽¹⁾			
Hr	Region	6hr accumulation	24hr accumulation
00Z	Canada	20111027	
	Eastern Canada	20111027	
	Western Canada	20111027	
06Z	Canada	20111027	
	Eastern Canada	20111027	
	Western Canada	20111027	
12Z	Canada	20111027	20111027
	Eastern Canada	20111027	20111027
	Western Canada	20111027	20111027
18Z	Canada	20111027	
	Eastern Canada	20111027	
	Western Canada	20111027	



(1): Based on the CaPA system

Datamart

<http://www.weatheroffice.gc.ca/grib>



The screenshot shows a web browser window with the address bar displaying www.weatheroffice.gc.ca/grib/grib2_RDPA_ps15km_e.html. The page header includes the Environment Canada logo and the word "Canada". The main banner features a red maple leaf and the text "Weatheroffice www.weatheroffice.gc.ca". A navigation bar contains links for "Français", "Home", "Contact Us", "Help", "Search", and "canada.gc.ca". Below the navigation bar, a breadcrumb trail reads "Home > Analyses and Modelling > GRIB >". The left sidebar contains a list of links: "Warnings", "Current Conditions & Forecasts", "Radar & Satellite", "Marine Info", "Air Quality", "Aviation Weather", "Analyses & Modelling" (highlighted in red), "Text Bulletins", "Historical Weather", "Educational Resources", "About Us", "FAQ", "Links", "Site Map", and "Proactive Disclosure". The main content area has the heading "High Resolution Digital Data - Regional Deterministic Precipitation Analysis (RDPA - CaPA) - GRIB2 format". The text describes the RDPA system, its resolution, and the GRIB2 dataset. A "Download" section explains how to access the data via HTTP and provides a URL. A list of parameters is shown at the bottom.

High Resolution Digital Data - Regional Deterministic Precipitation Analysis (RDPA - CaPA) - GRIB2 format

The Regional Deterministic Precipitation Analysis (RDPA) based on the Canadian Precipitation Analysis (CaPA) system is on a domain that corresponds to that of the operational regional model, i.e. the Regional Deterministic Prediction System (RDPS LAM3D) except for areas over the Pacific ocean where the western limit of the RDPA domain is slightly shifted eastward with respect to the regional model domain. The resolution of the RDPA analysis is identical to the resolution of the [operational regional model RDPS LAM3D](#). The fields in the RDPA GRIB2 dataset are on a polar-stereographic (PS) grid covering North America and adjacent waters with a 15 km resolution at 60 degrees north.

Download

The data is available using the HTTP protocol and resides in a directory that is plainly accessible to a web browser. Visiting that directory with an interactive browser will yield a raw listing of links, each link being a downloadable [GRIB2](#) file. In practice, we recommend writing your own script to automate the downloading of the desired data (using [wget](#) or equivalent). If you are unsure of how to proceed, you might like to take a look at our brief [usage guide](#).

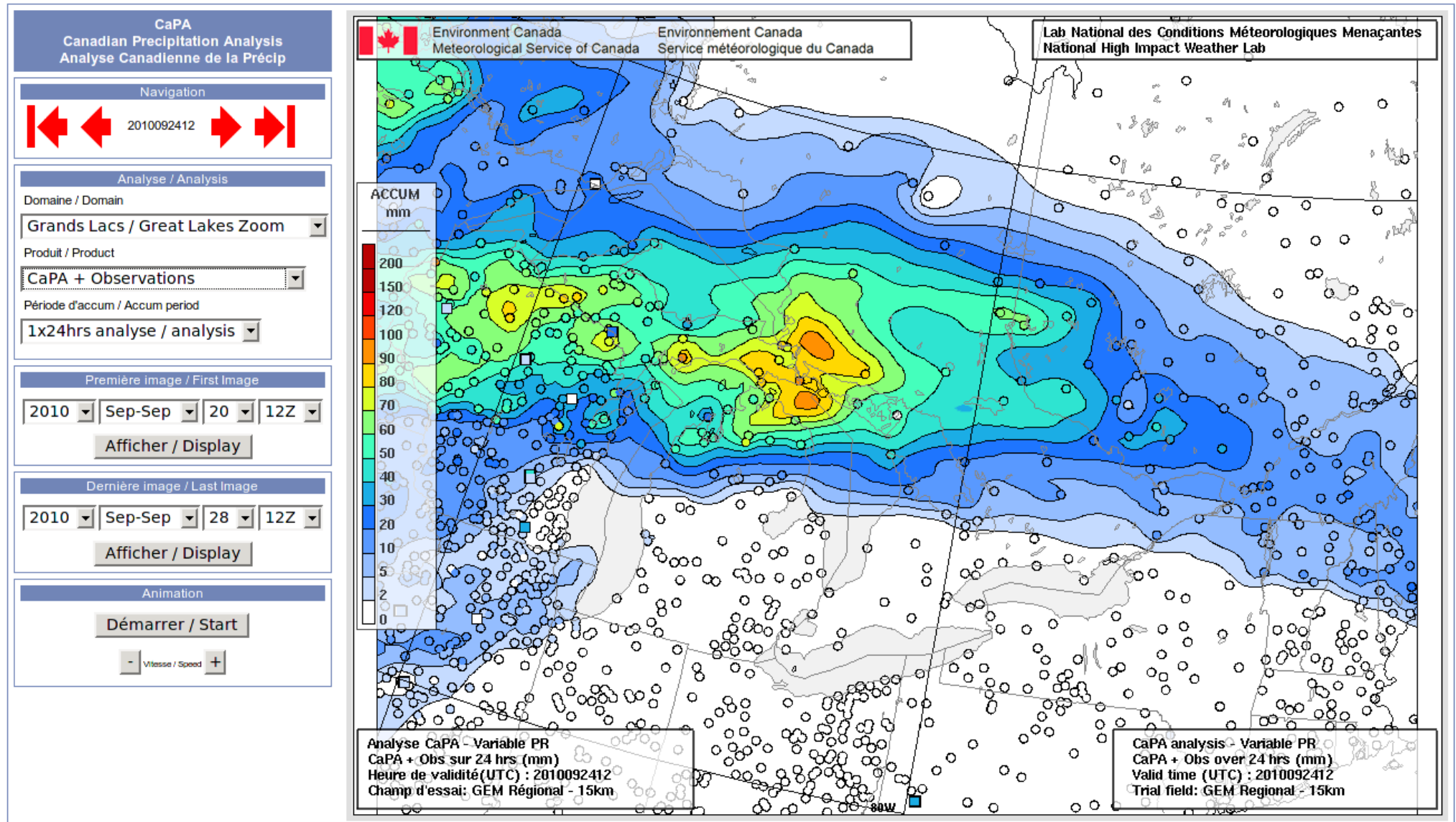
The data can be accessed at the following URLs:
http://dd.weatheroffice.gc.ca/analysis/precip/rdpa/grib2/polar_stereographic/hh

where:

- **hh**: time interval of 06 or 24 hours in which precipitation accumulations are analyzed

Experimental web site

<http://loki.qc.ec.gc.ca/DAI/CaPA>





Environment Canada
Meteorological Service of Canada

Environnement Canada
Service météorologique du Canada

Lab National des Conditions Météorologiques Menaçantes
National High Impact Weather Lab

PRECIP
mm

200
150
120
100
90
80
70
60
50
40
30
20
10
5
2
0

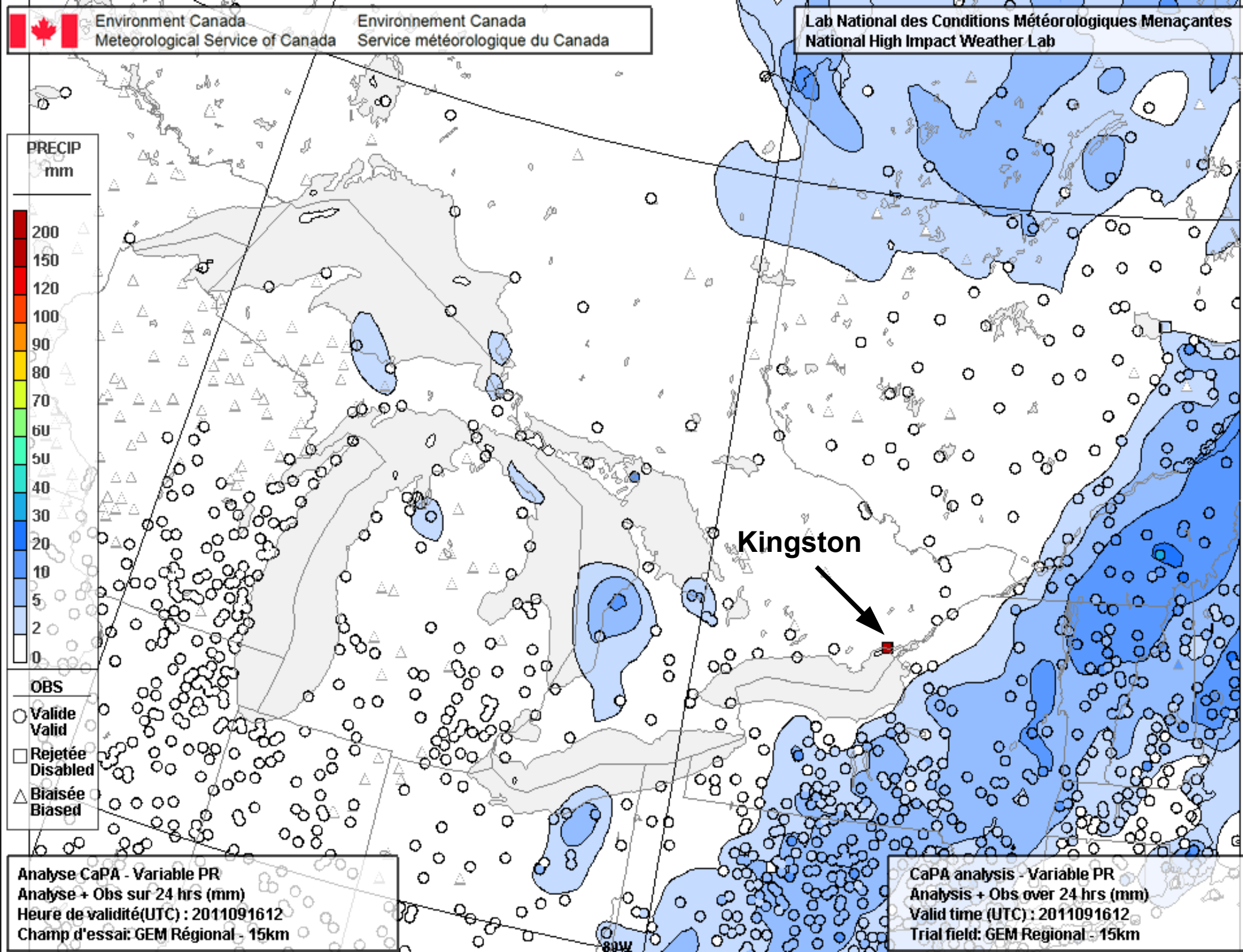
OBS

○ Valide
Valid
□ Rejetée
Disabled
△ Biaisée
Biased

Kingston

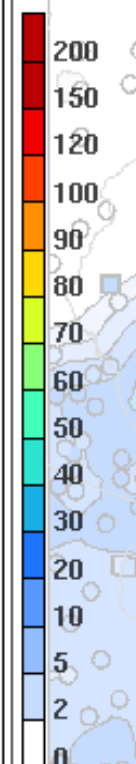
Analyse CaPA - Variable PR
Analyse + Obs sur 24 hrs (mm)
Heure de validité(UTC) : 2011091612
Champ d'essai: GEM Régional - 15km

CaPA analysis - Variable PR
Analysis + Obs over 24 hrs (mm)
Valid time (UTC) : 2011091612
Trial field: GEM Regional - 15km





PRECIP
mm



OBS

- Valide
Valid
- Rejete
Disabled
- △ Biaisé
Biased

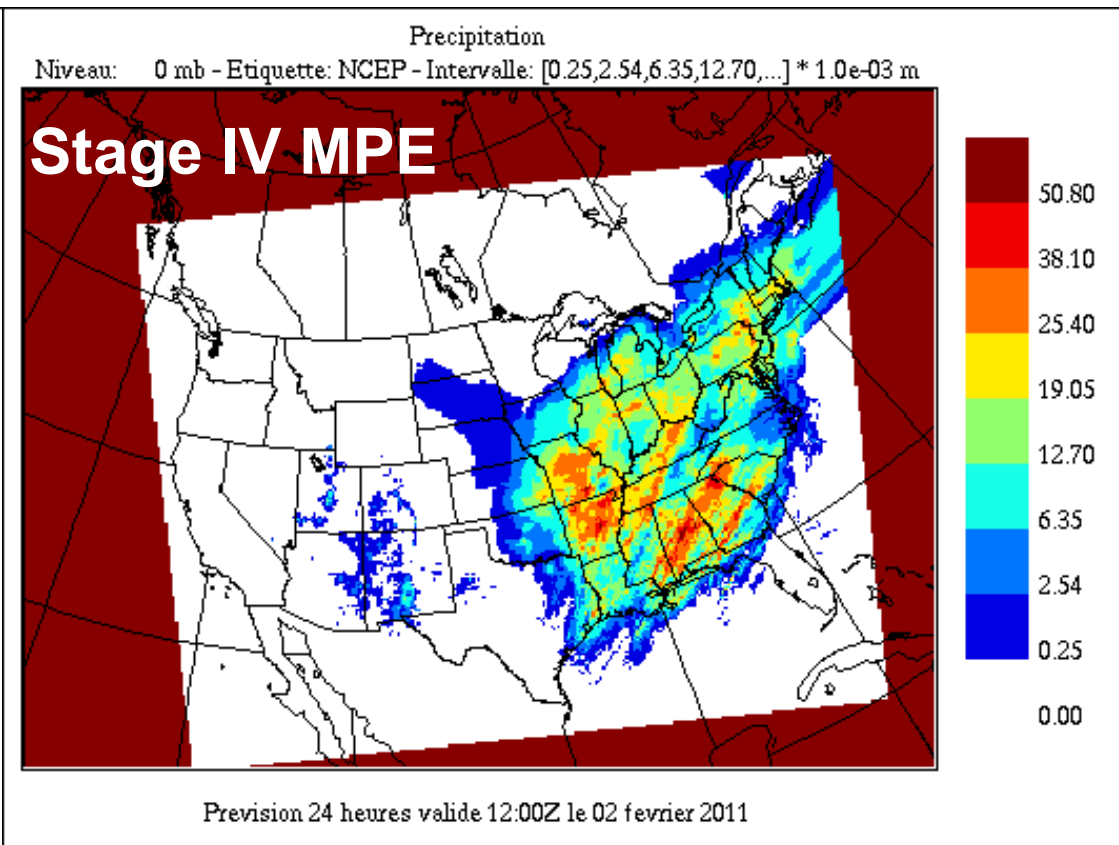
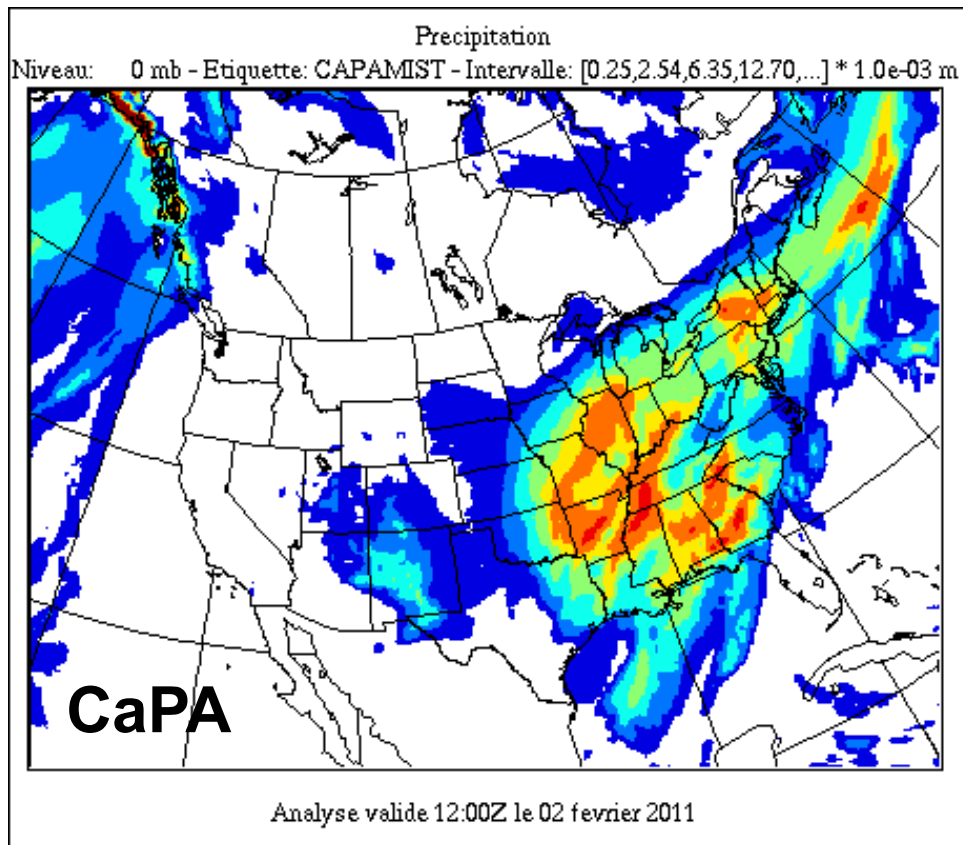
Analyse CaPA - Variable PR
Analyse + Obs sur 24 hrs (mm)
Heure de validit(UTC) : 2011092712
Champ d'essai: GEM Rgional - 15km

False zeros?

CaPA analysis - Variable PR
Analysis + Obs over 24 hrs (mm)
Valid time (UTC) : 2011092712
Trial field: GEM Regional - 15km

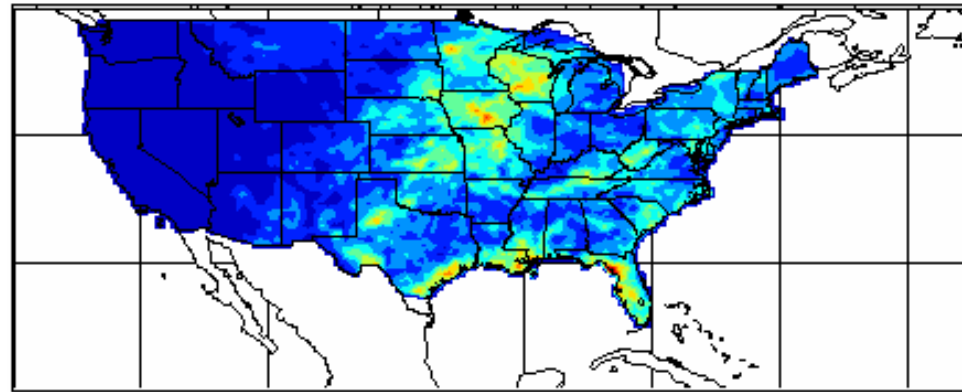
Groundhog day storm

24h accum valid 2011-02-02@12Z



Summer 2010: CaPA vs MPE and CPC

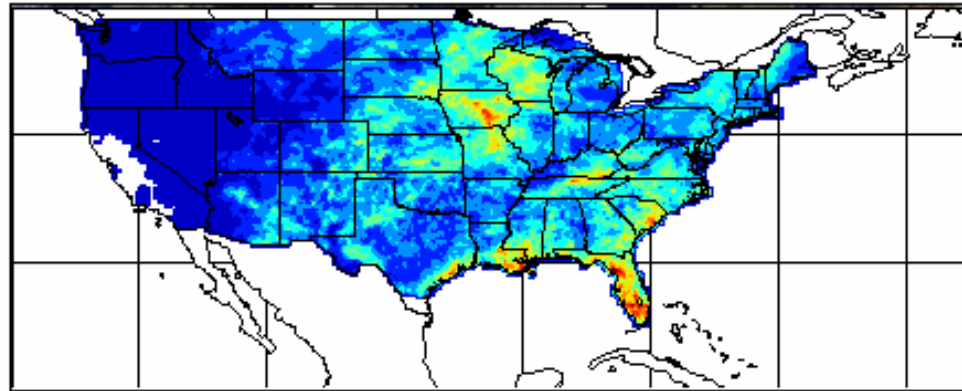
Niveau: 0 mb - Etiquette: CAPA22RC2 - Intervalle: 1 * 1.0e-03 m



CaPA



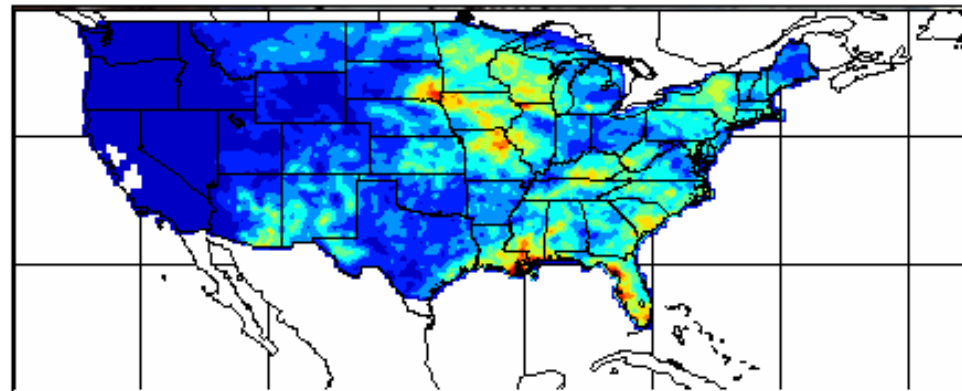
Niveau: 0 mb - Etiquette: NCEP - Intervalle: 1 * 1.0e-03 m



**Stage IV
MPE**



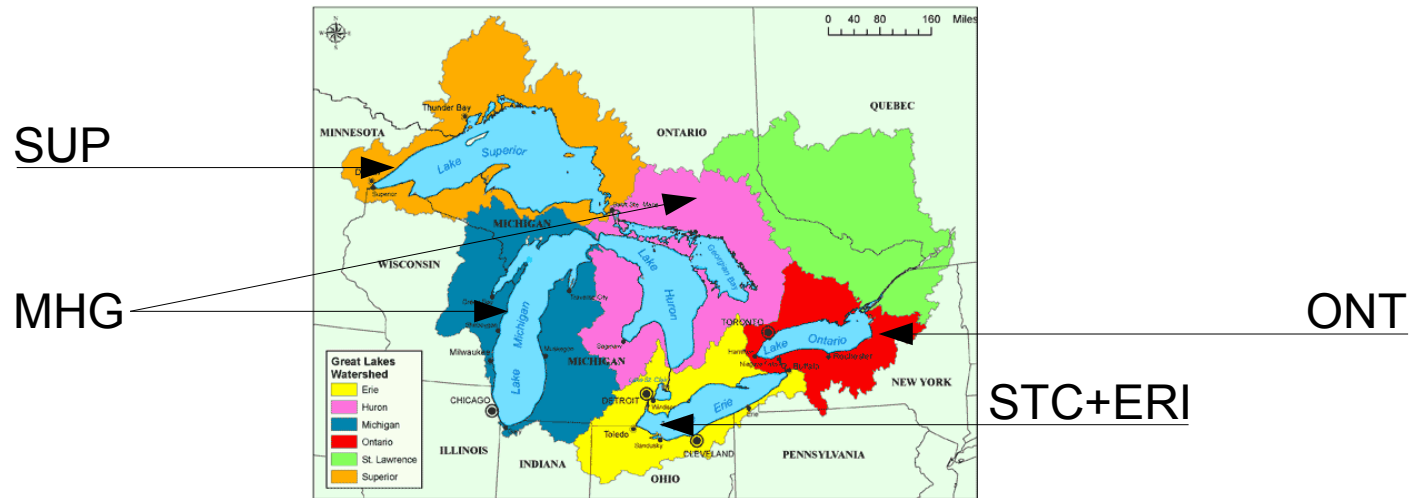
Niveau: 0 mb - Etiquette: CPC - Intervalle: 1 * 1.0e-03 m



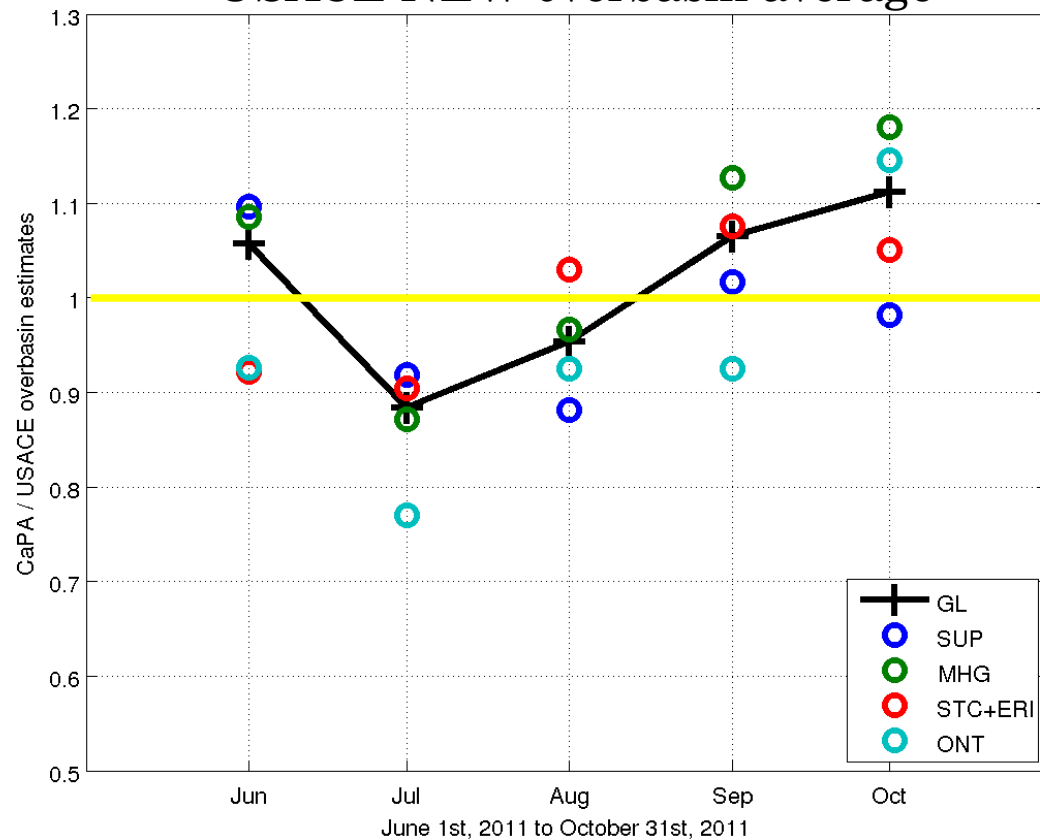
CPC



ρ	CaPA	MPE	CPC
CaPA	1	0.93	0.93
MPE	0.93	1	0.92
CPC	0.93	0.92	1



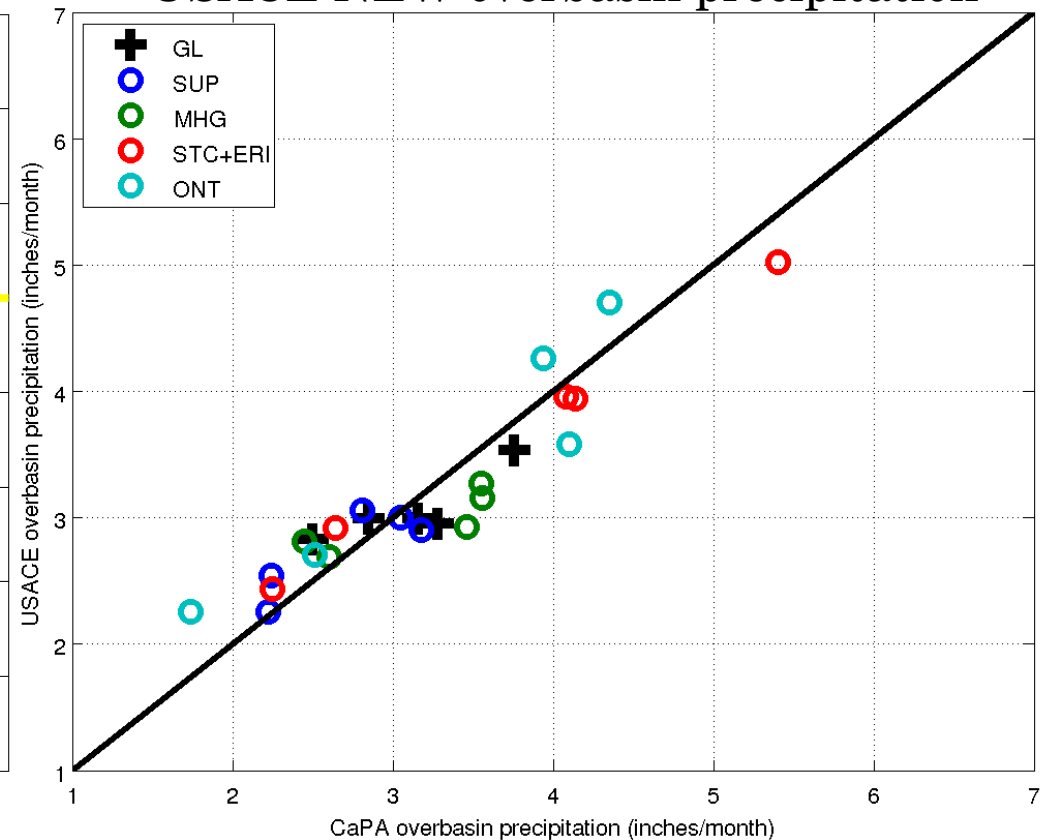
Ratio of CaPA to
USACE NEW overbasin average



Summer

Fall

CaPA vs
USACE NEW overbasin precipitation



Verification of Overlake Evaporation

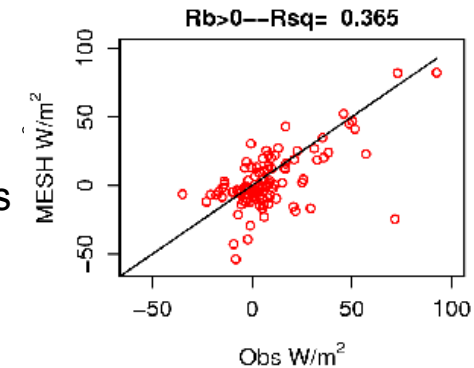
Eddy-correlation system

Observations
courtesy of
Chris Spence,
NWRI

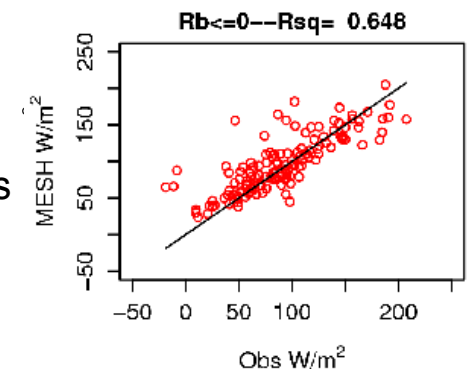


Verification of daily mean flux (June 2008 – January 2009)

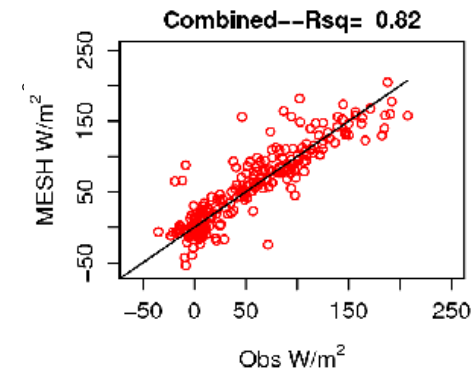
Stable
conditions



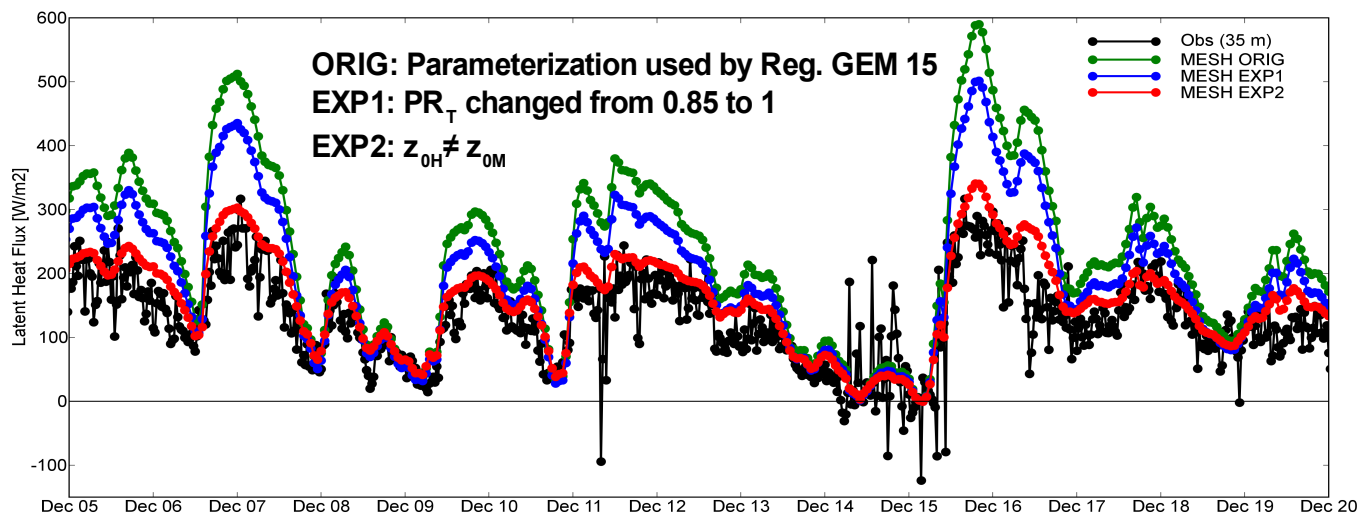
Unstable
conditions



All cases



Verification of half-hourly fluxes for December 2008:



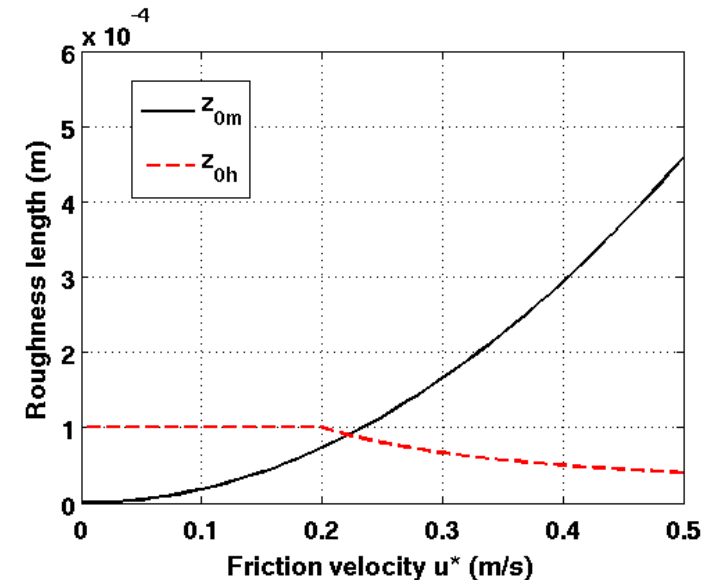
Modifying the Surface Turbulent Flux

Parameterization over Water

Momentum roughness length: $z_{0m} = 0.018 \frac{u_f^2}{g}$

Scalar roughness length: $z_{0h} = \min\left(\frac{0.2}{u_f}, 1\right) \times 10^{-4}$

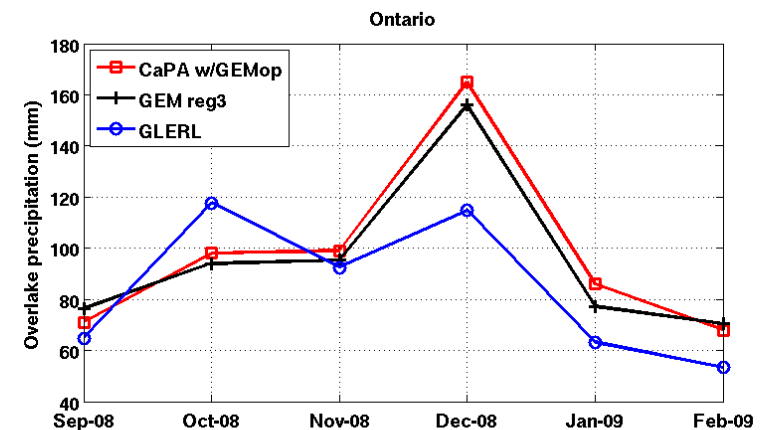
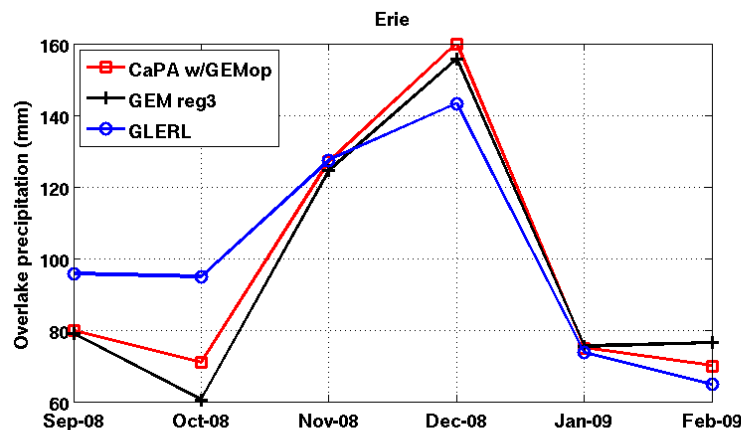
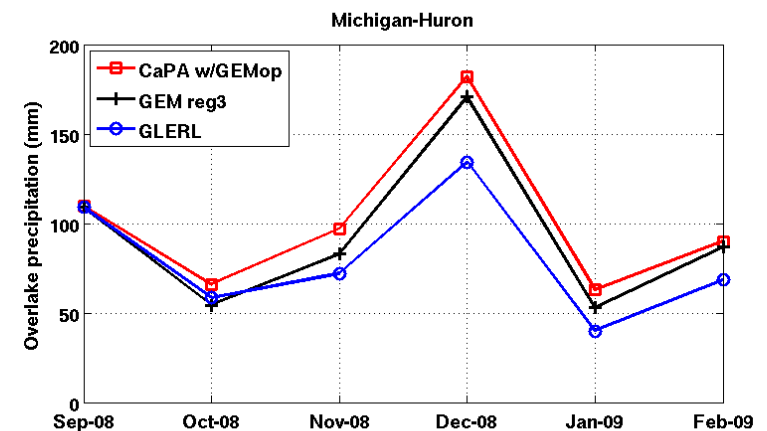
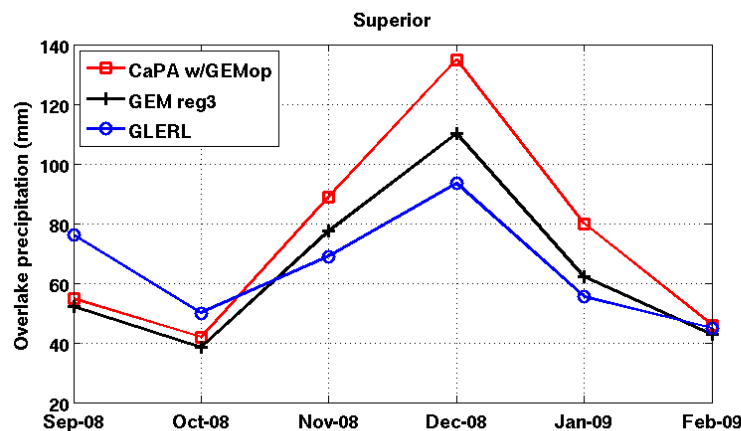
U_f = friction velocity, g = gravitational acceleration



Surface Flux Parameterization	z_{0m}	z_{0h}	Prandtl number	$Pr_T = \epsilon_m / \epsilon_h$
Original	Eq. 1	Eq. 1	0.85	
EXP1	Eq. 1	Eq. 1	1	
EXP2 (final)	Eq. 1	Eq. 2	1	

Impact of improvements to GEM evaporation on precipitation

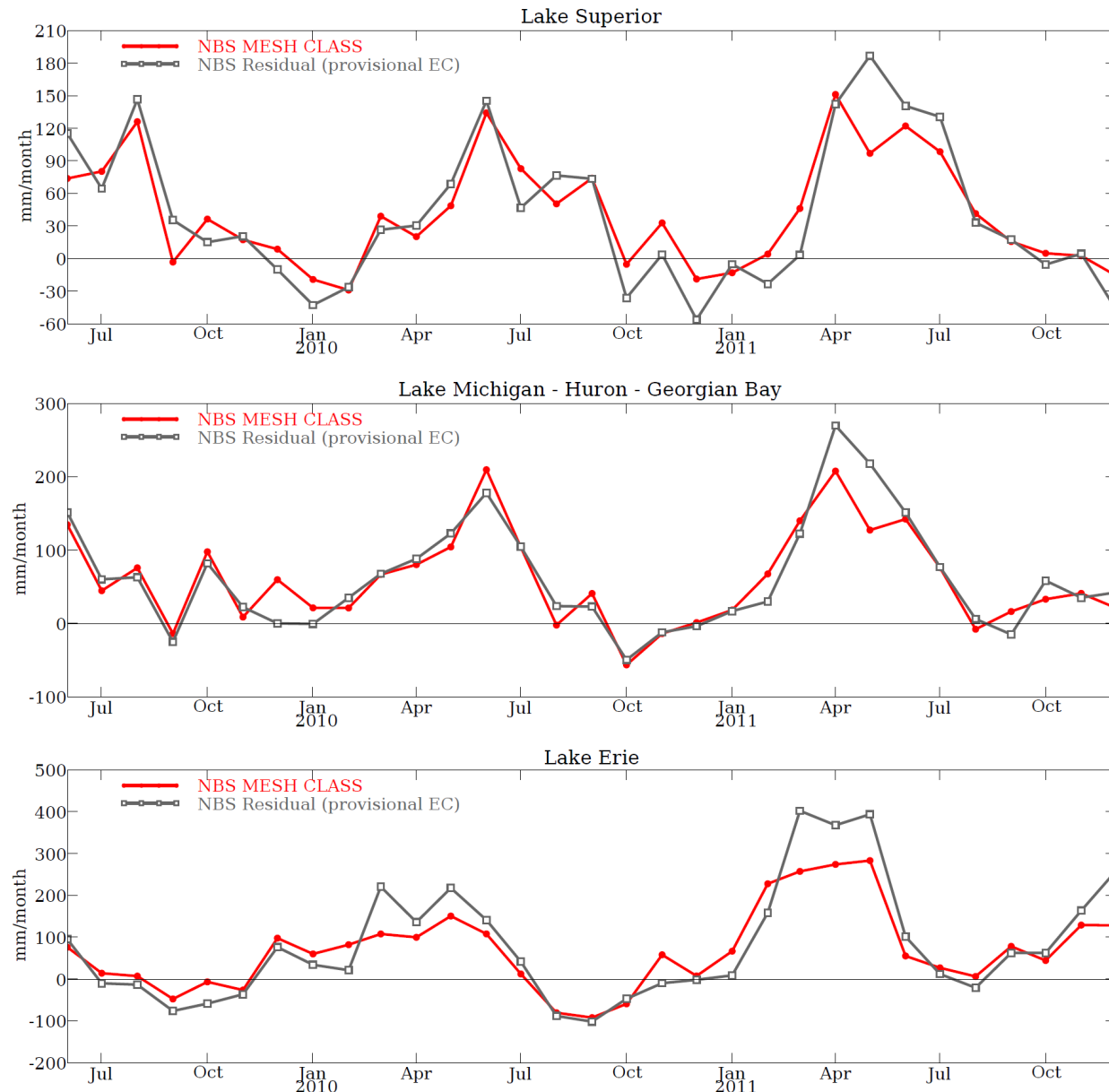
- Reduction in evaporation brings reduction in precipitation
- Still quite different from GLERL land-based estimate!
- These changes should make it into next op. version of GEM



Hydrological prediction of Net Basin Supply to the Great Lakes using CaPA

MESH model

- CLASS land-surface scheme
- WATROUTE routing model
- GEM RDPS forcing, 6h-12h lead time
 - except for precip for which CaPA is used



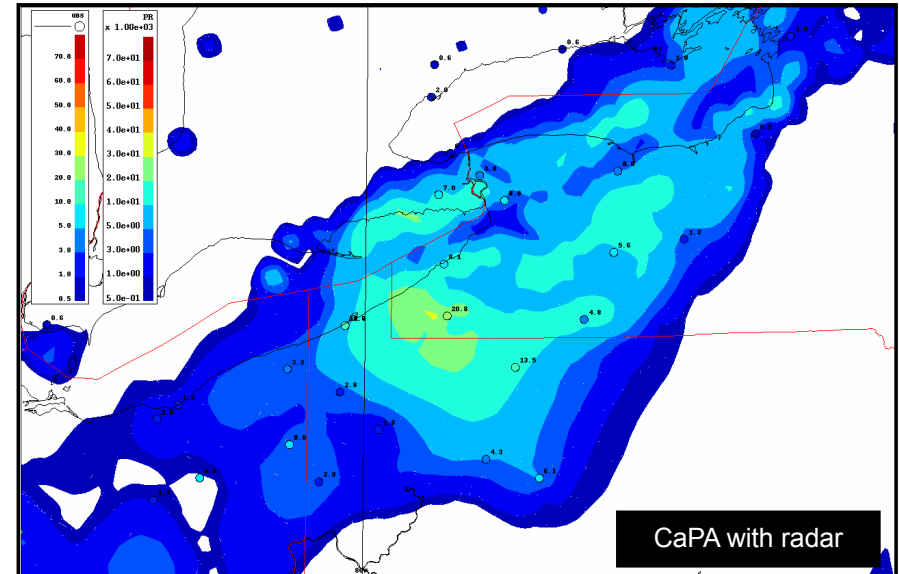
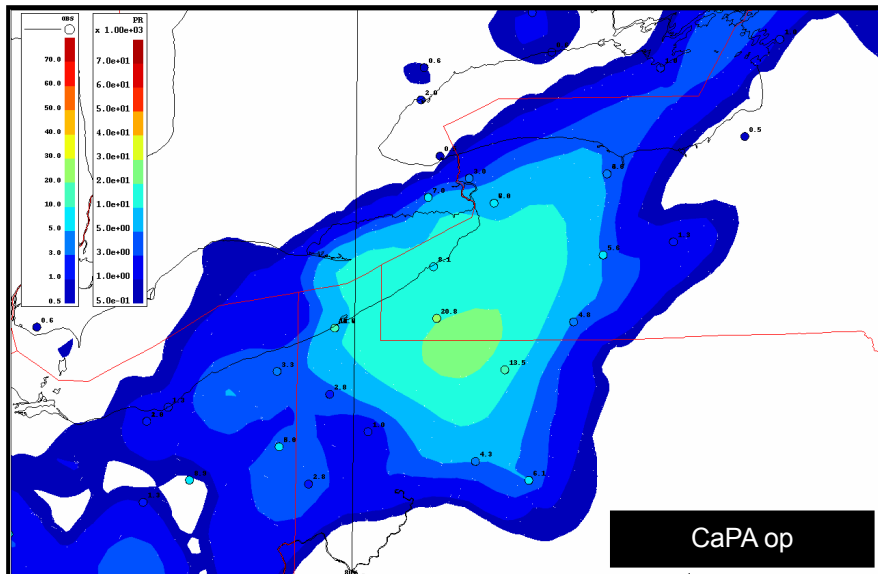
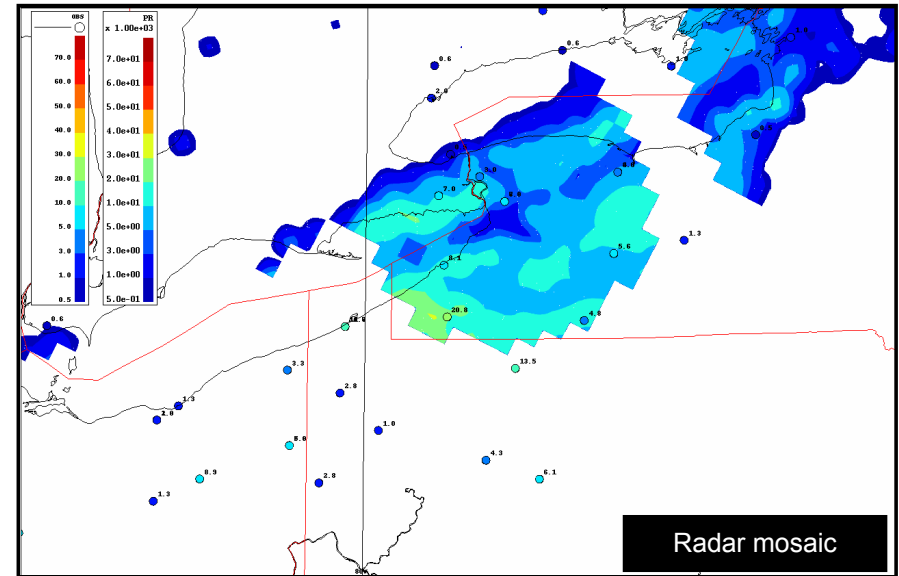
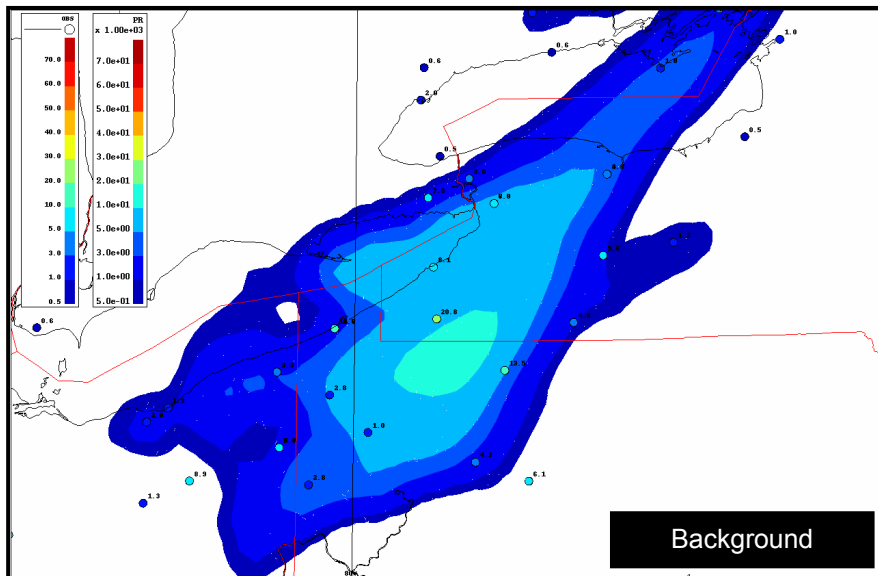
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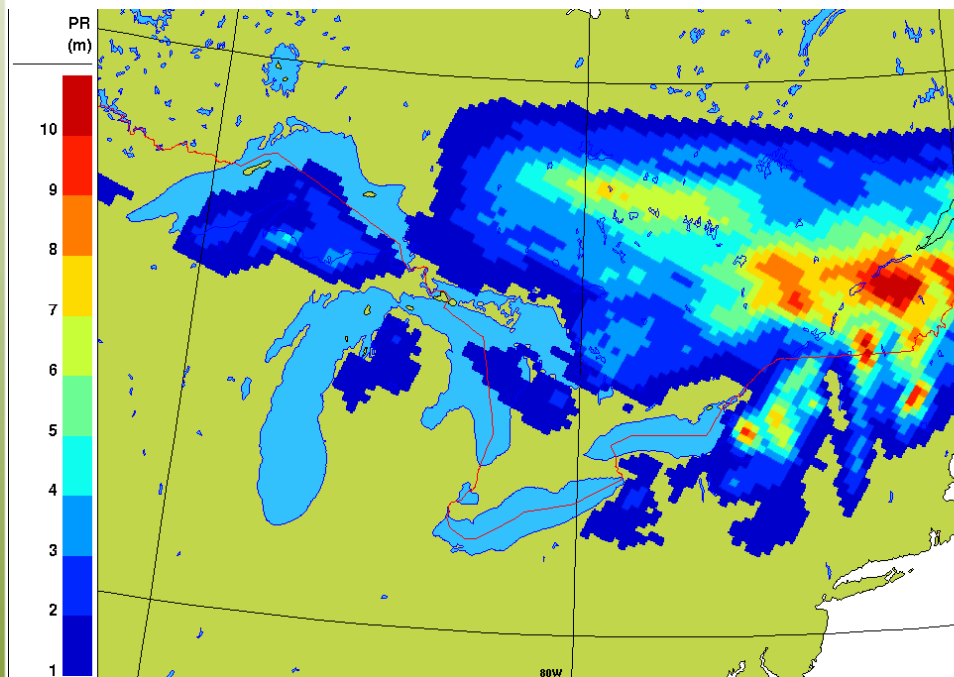
Environment
Canada

Assimilation of radar QPE, 2011-08-21 12 UTC (6h accumulation)

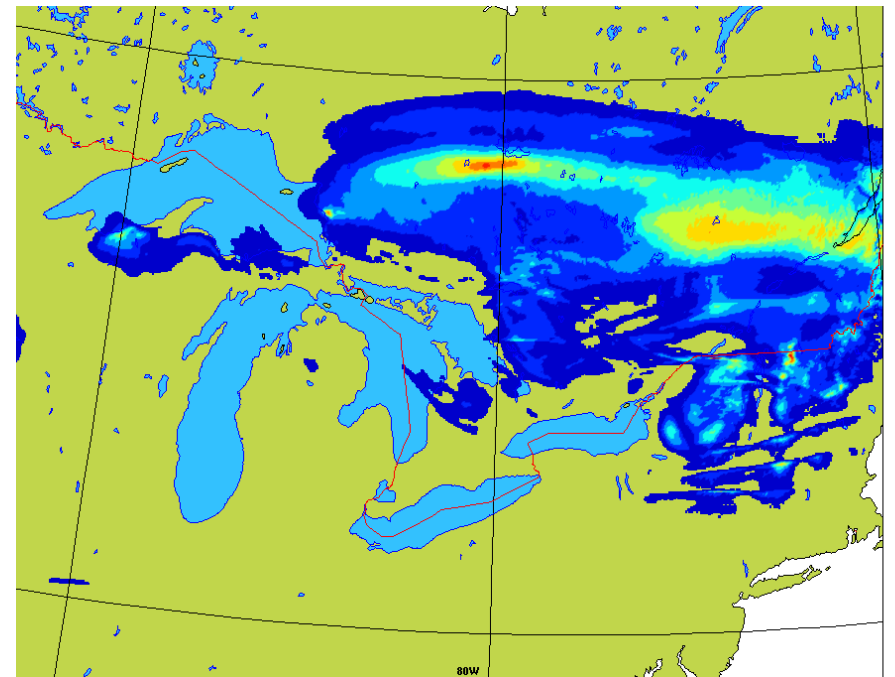


Experimental GEM-LAM 2.5 km window: Towards a hourly, 2.5km version of CaPA

GEM 15km RDPS (CaPA background)



GEM-LAM east 2.5km HRDPS



24h forecast of cumulative precipitation
valid 2012-02-28 12 UTC
issued 2012-02-27 12 UTC



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CaPA on the web

- Operational web site: images
<http://www.weather.gc.ca/analysis/>
- GRIB 2 files on the datamart
http://www.weatheroffice.gc.ca/grib/grib2_RDPA_ps15km_f.html
- Experimental web site
<http://loki.qc.ec.gc.ca/DAI/CaPA>





ACCÈS INTERDIT SANS AUTORISATION
PAS DE CIRCULATION

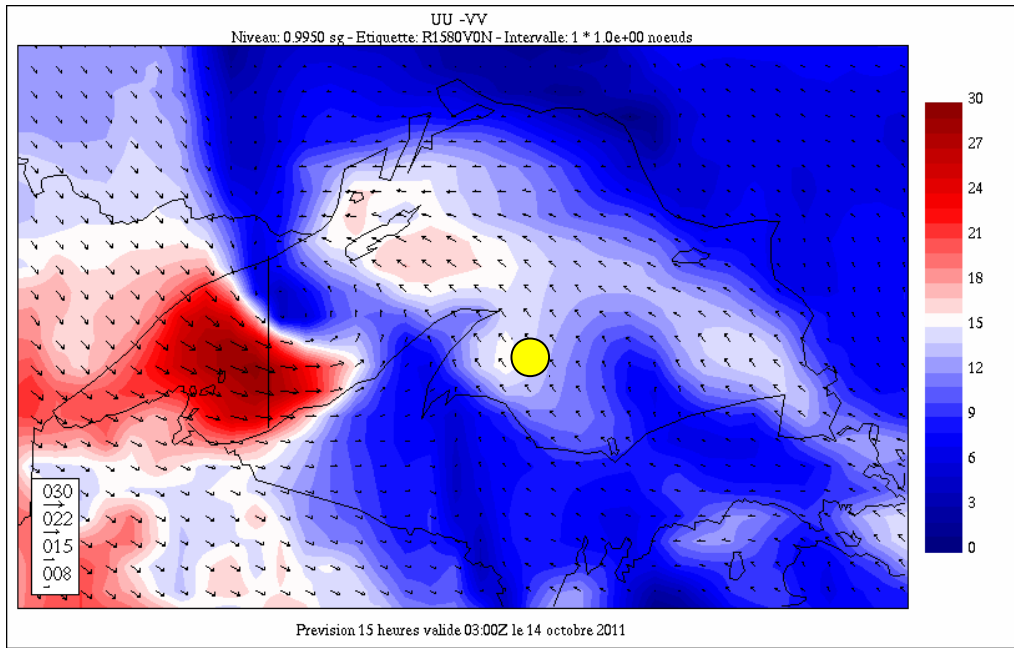
ACCÈS INTERDIT SANS AUTORISATION
PAS DE CIRCULATION

ACCÈS INTERDIT SANS AUTORISATION
PAS DE CIRCULATION

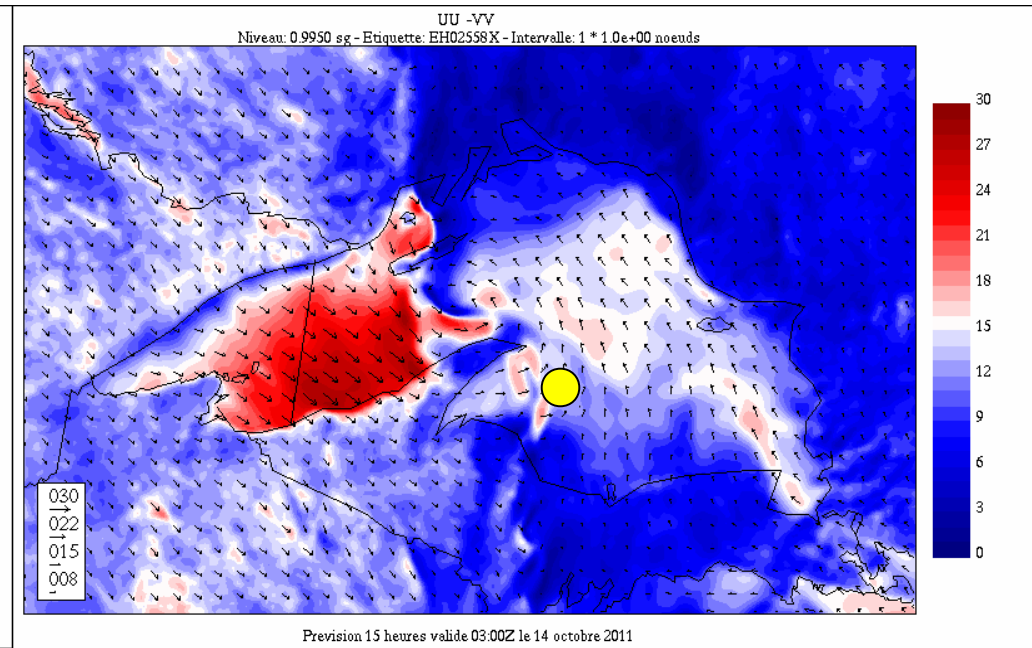
SAINT-JEAN-SUR-RICHELIEU

Wind field as seen by 15km and 2.5km GEM model as the frontal system is passing over Stannard Rock

GEM 15 km

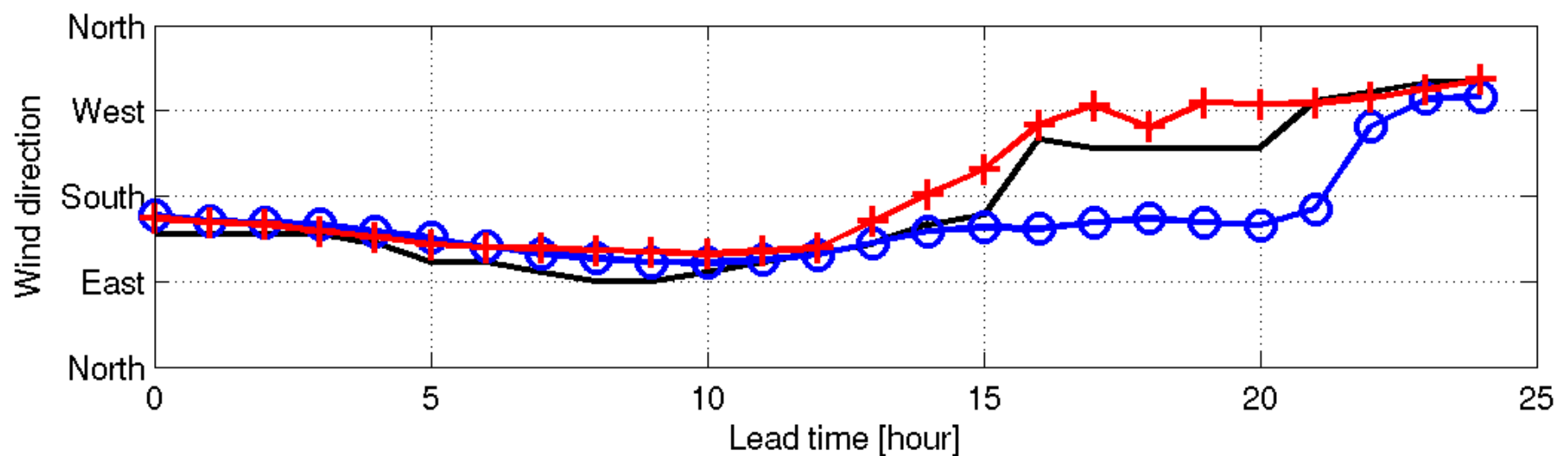
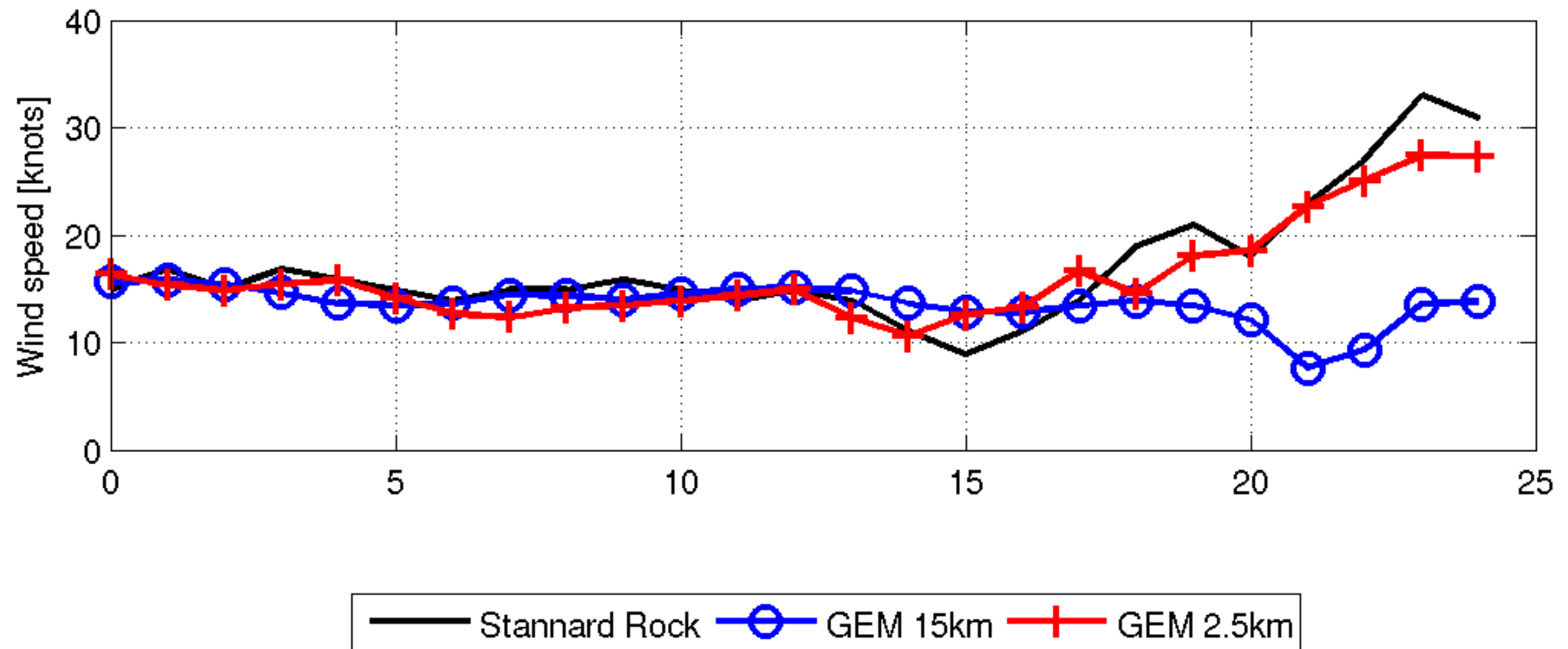


GEM 2.5 km



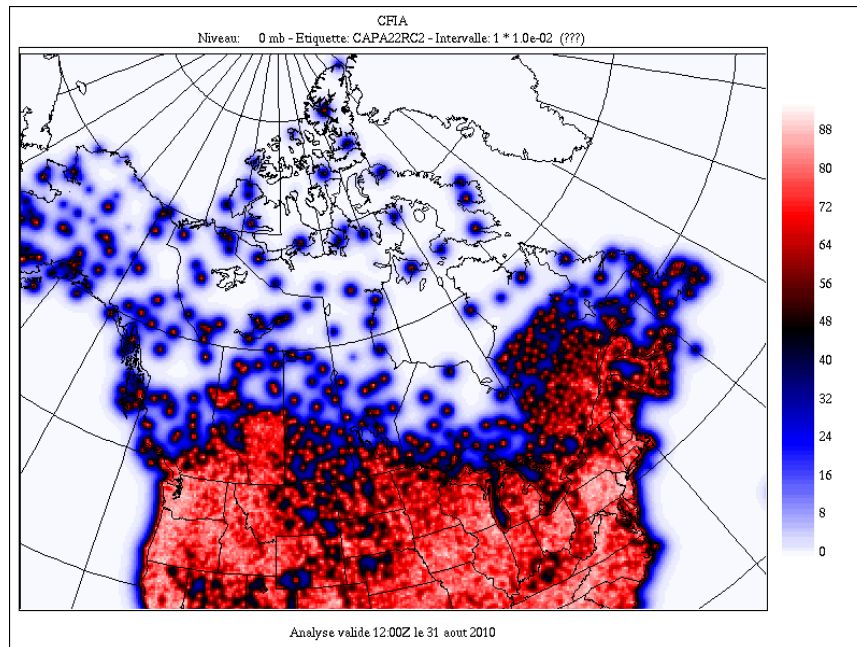
Forecast issued at 12 UTC, Oct. 13, 2011
Valid at 03 UTC, Oct. 14, 2011

Verification of GEM 15km and GEM 2.5km wind forecast (40 m height)
vs Stannard Rock Lighthouse (35 m height), Lake Superior
Forecast issued at 2011-10-13 12Z

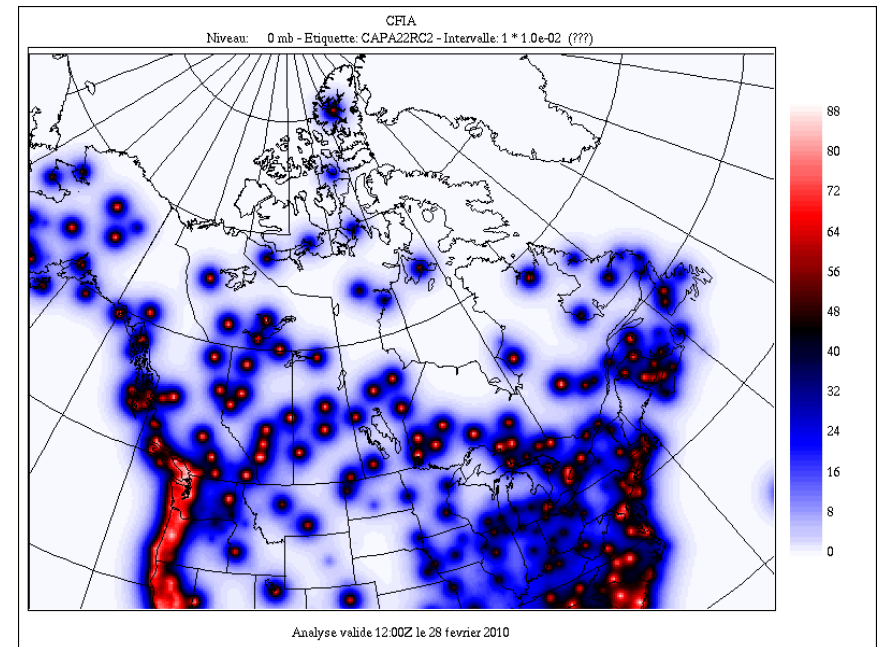


Mean value of confidence index (24h analysis)

JJA 2010



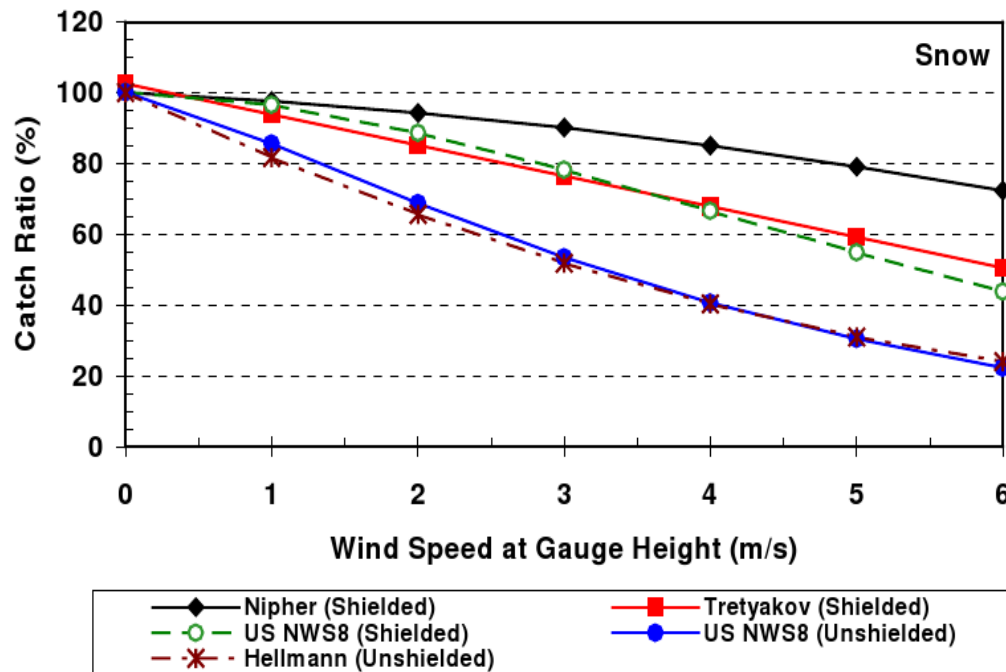
DJF 2010



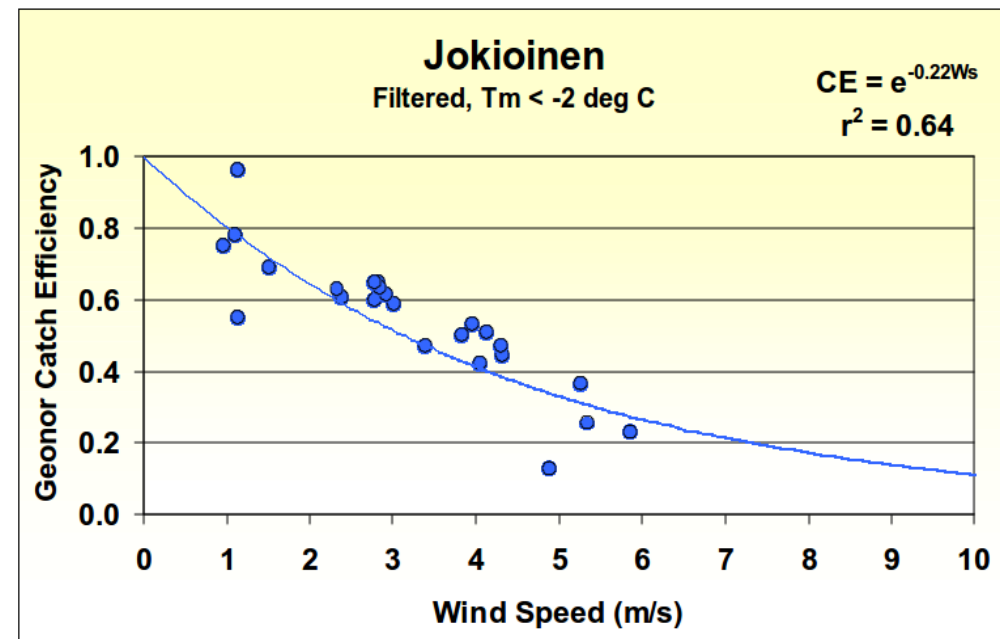
Catch efficiency of various gauges vs WMO secondary ref. (DFIR)

- For cold snow ($T_{max} < -2^{\circ}\text{C}$), things are worse for wet snow!

Manned gauges (WMO 1989)



Geonor gauge with Alter shield



Courtesy of Craig Smith

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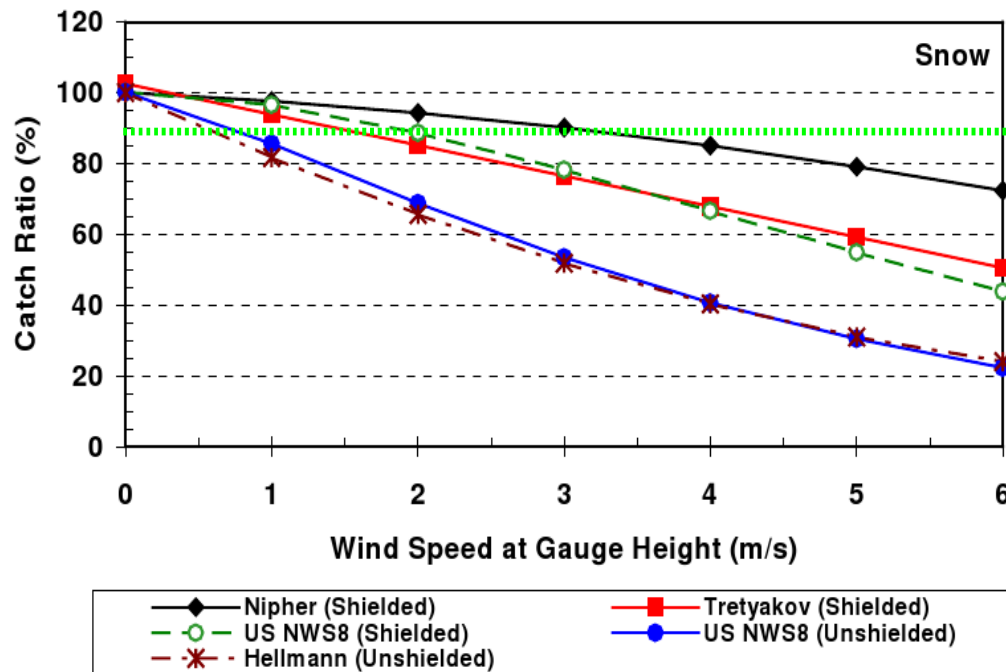
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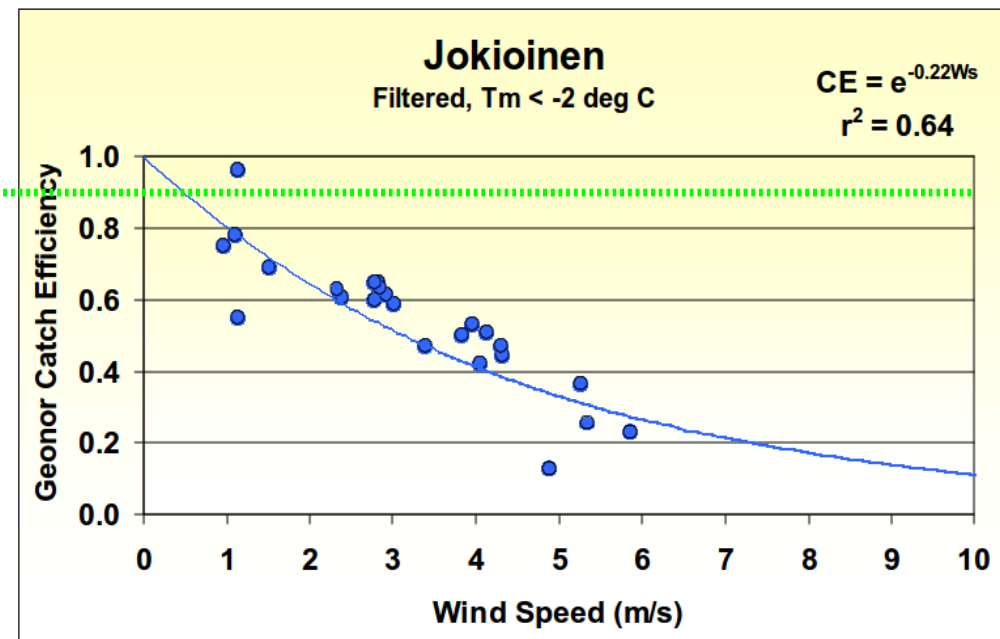
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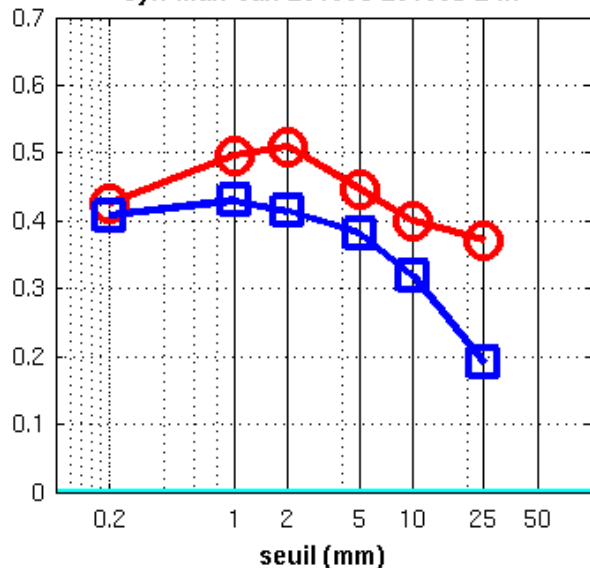
Strategy for assimilation of solid precipitation observations

- If not available, estimate mean wind speed at gauge height from 10m wind speed assuming log profile (UV_{2m})
- Accept obs. stations only if UV_{2m} less or equal to:
 - 3 m/s for Canadian manned synoptic gauges
 - 2 m/s for US manned synoptic gauges
 - 0 m/s for automatic gauges
- Despite being very strict, this strategy was shown to improve bias and ETS of analysis vs assimilating all obs.
- Bias-correction procedure would be preferable (currently under development)
 - Requires additional data (temperature, wind speed) and metadata not currently available at all stations (eg wind shield type)

JJA 2010

ETS (PR \geq seuil)

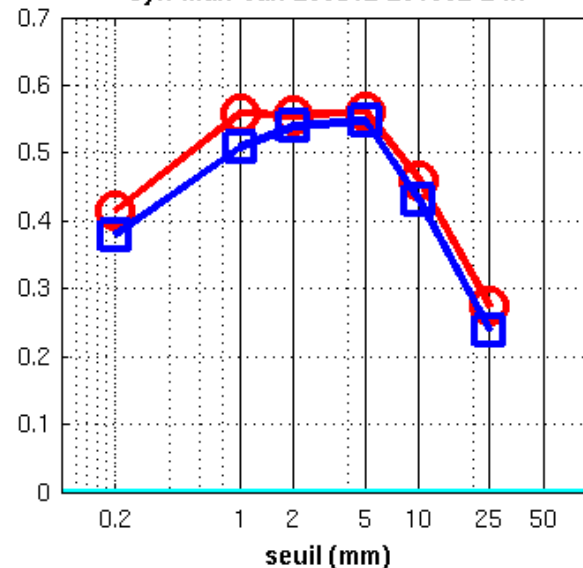
syn-man-can-201006-201008-24h



DJF 2010

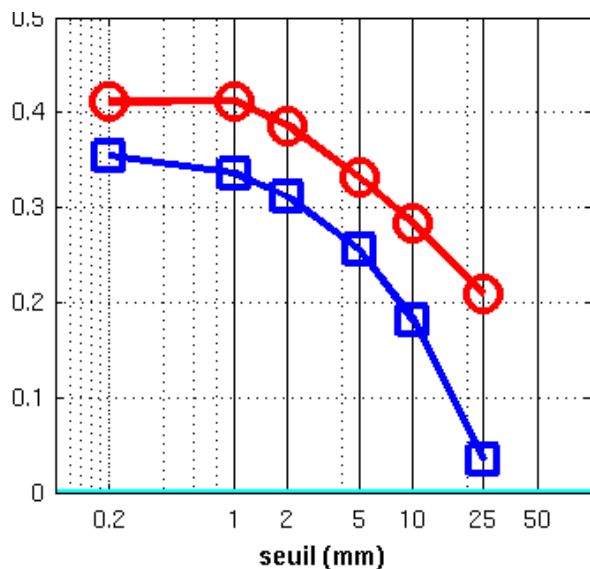
ETS (PR \geq seuil)

syn-man-can-200912-201002-24h

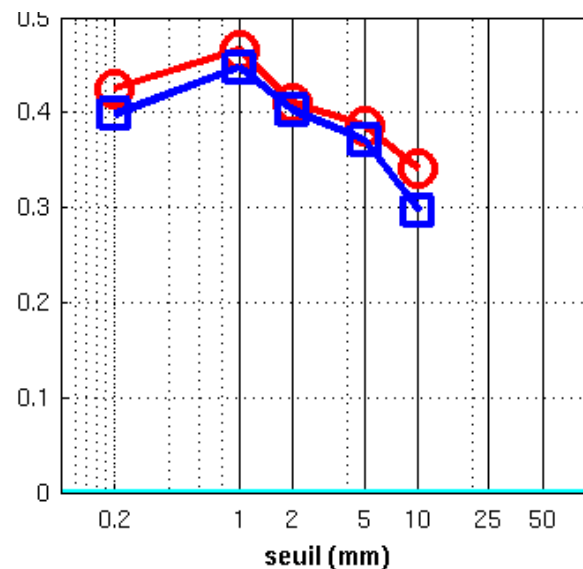


24h
vs
CMAN

A A A A A A ?



A A A ? ? ? ?



6h
vs
CMAN

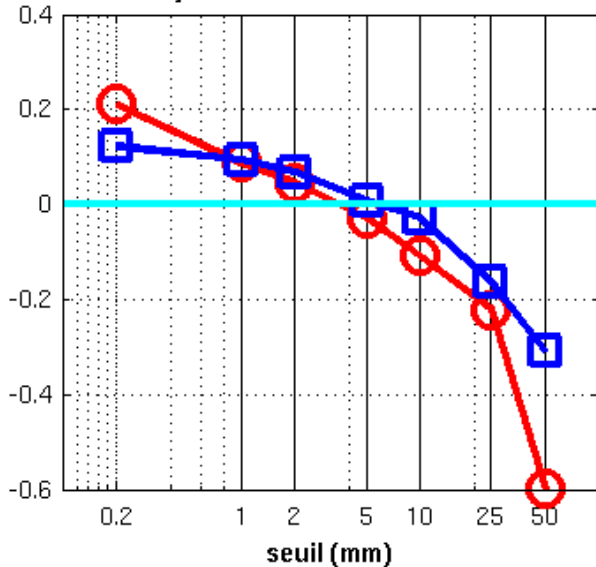
A A A A A A ?

A A ? ? ? ? ?

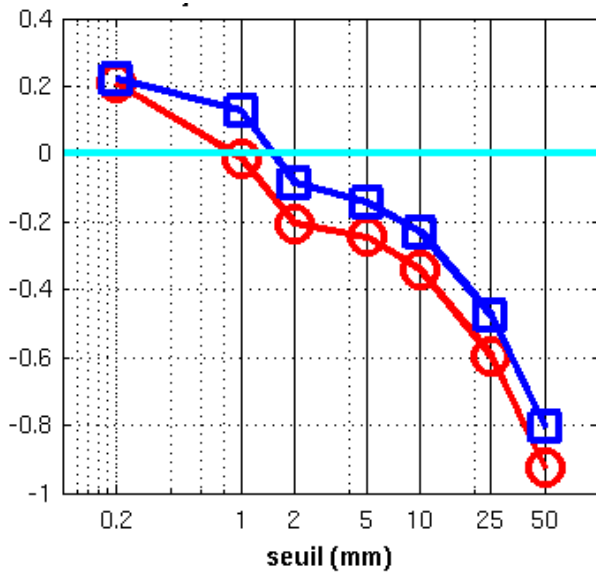
Equitable Threat Score (ETS)

JJA 2010

FBI-1 (PR \geq seuil)
syn-can-201006-201008-24h



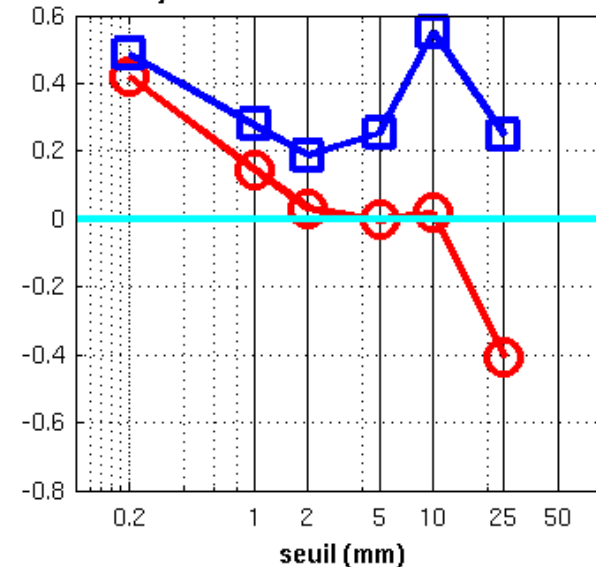
P ? A ? P P P



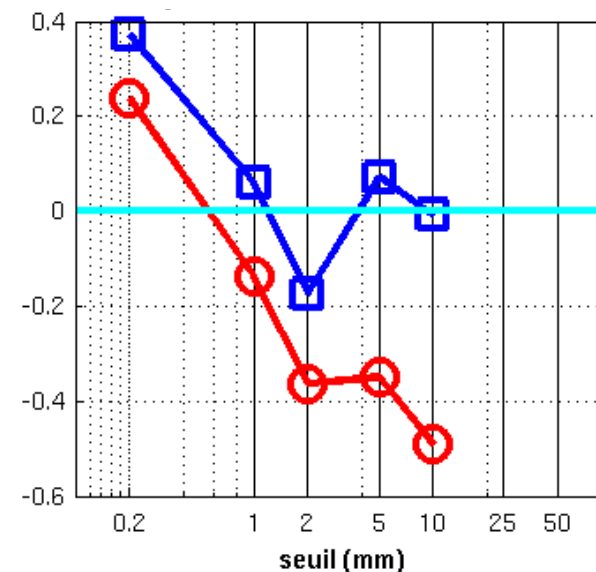
A A P P P P P

DJF 2010

FBI-1 (PR \geq seuil)
syn-man-can-200912-201002-24h



A A A A A ? ?

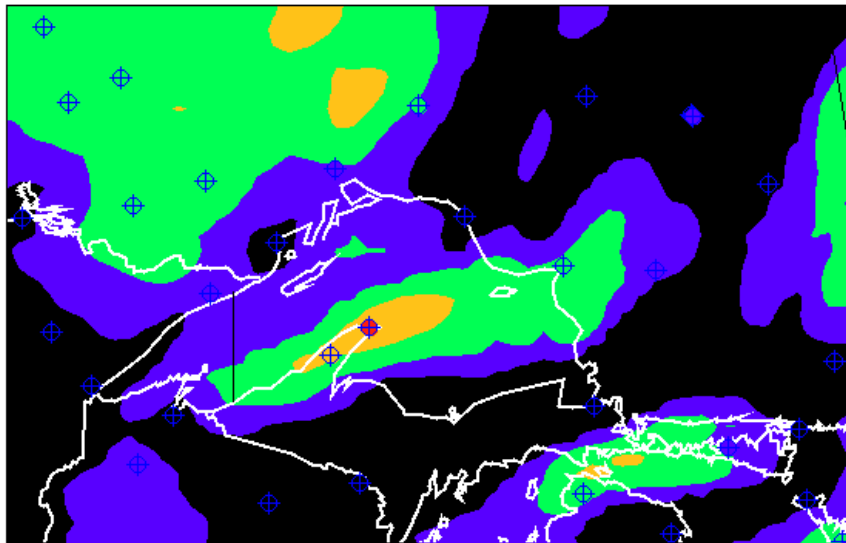


A P P P P ? ?

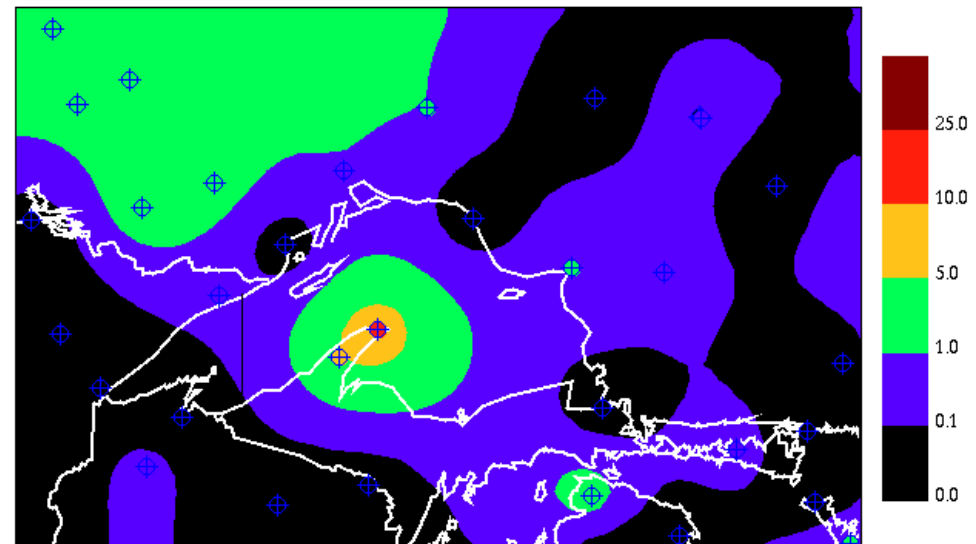
Frequency Bias Indicator (FBI) -1

CaPA vs Ordinary Kriging over Lake Superior

- Residual kriging: CaPA



- Ordinary kriging



6h accumulation valid on 2006-10-13 at 0Z

5-year average (June 2004 - May 2009) of GEM precip. with new surface roughness parameterization

Spring

Summer

mm /
day

7.0

6.0

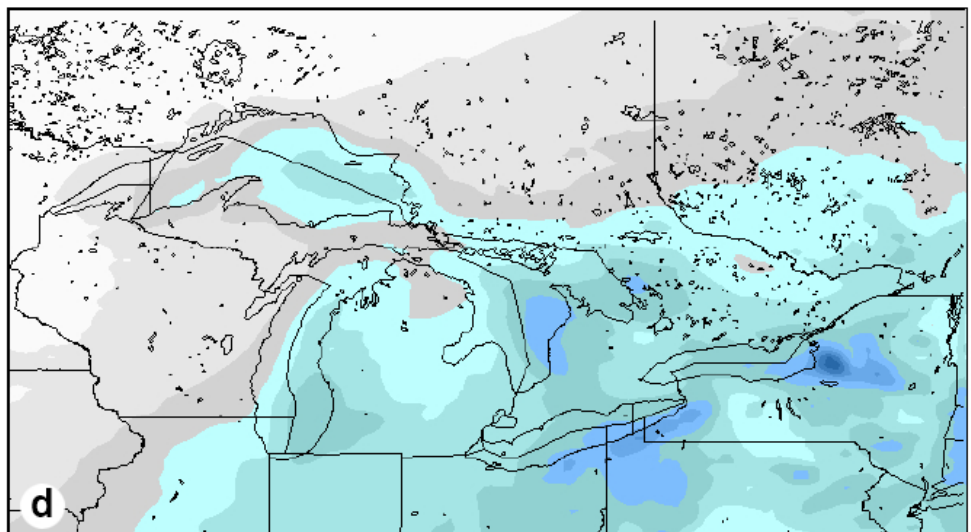
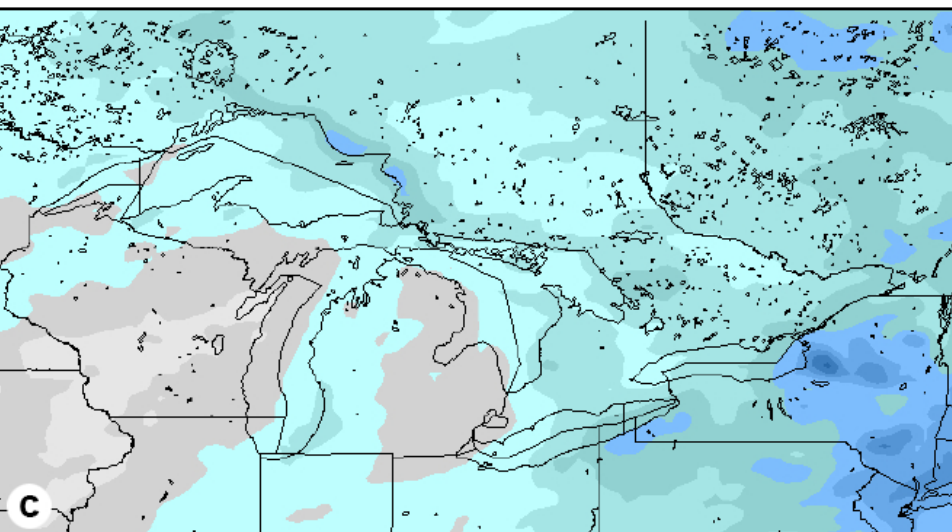
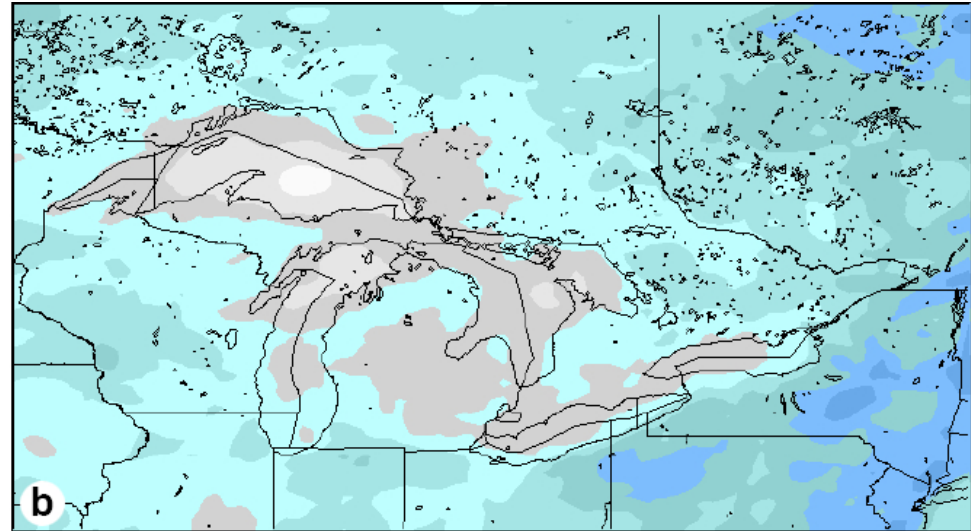
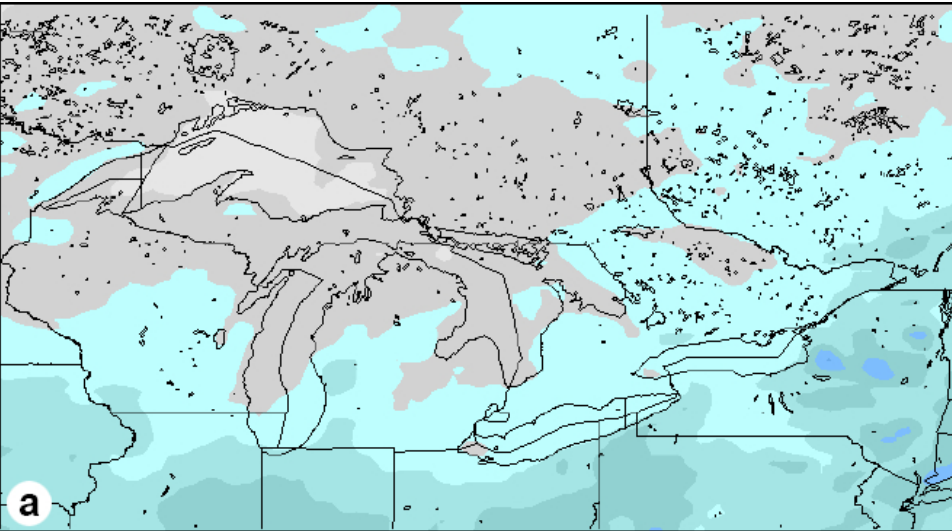
5.0

4.0

3.0

2.0

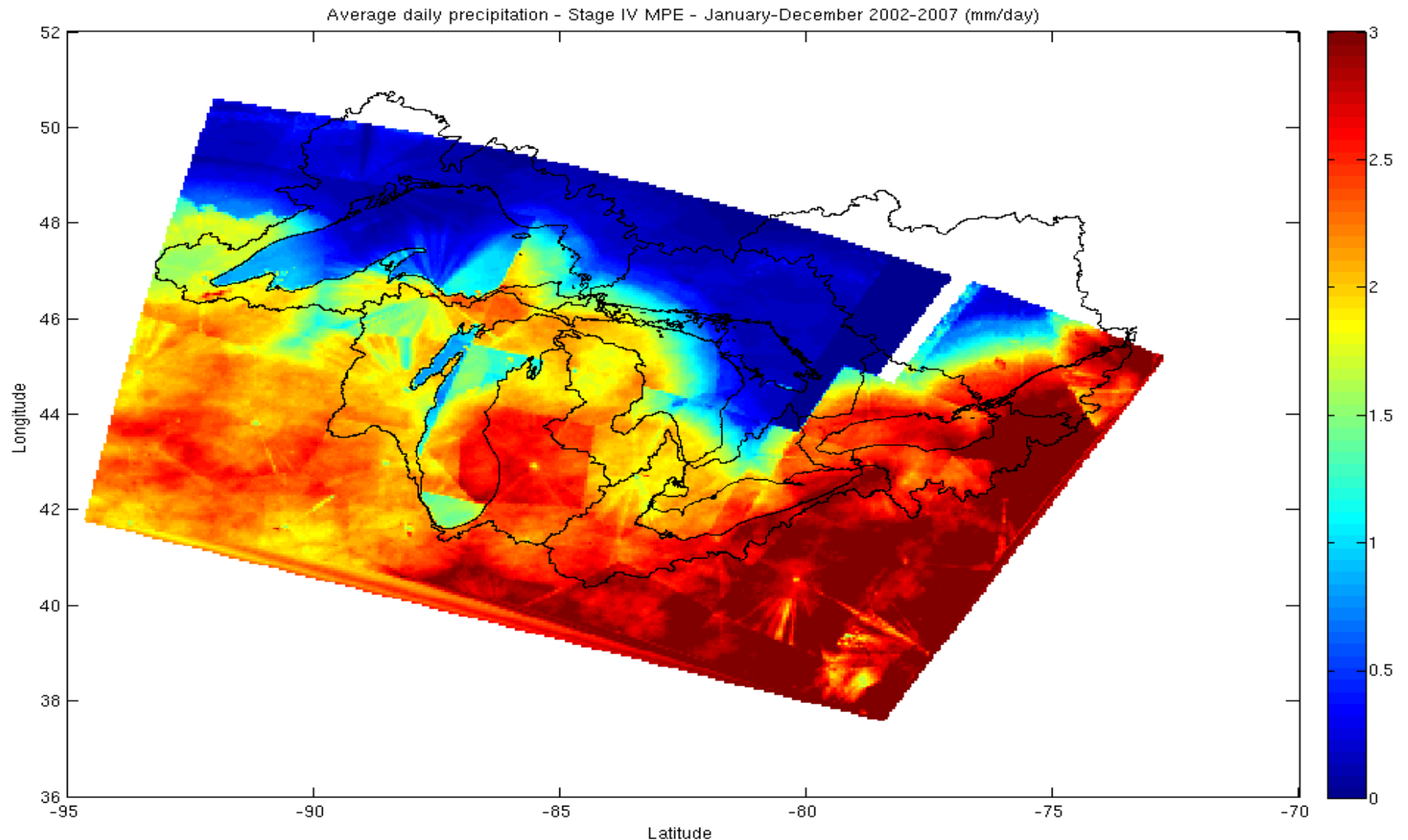
1.0



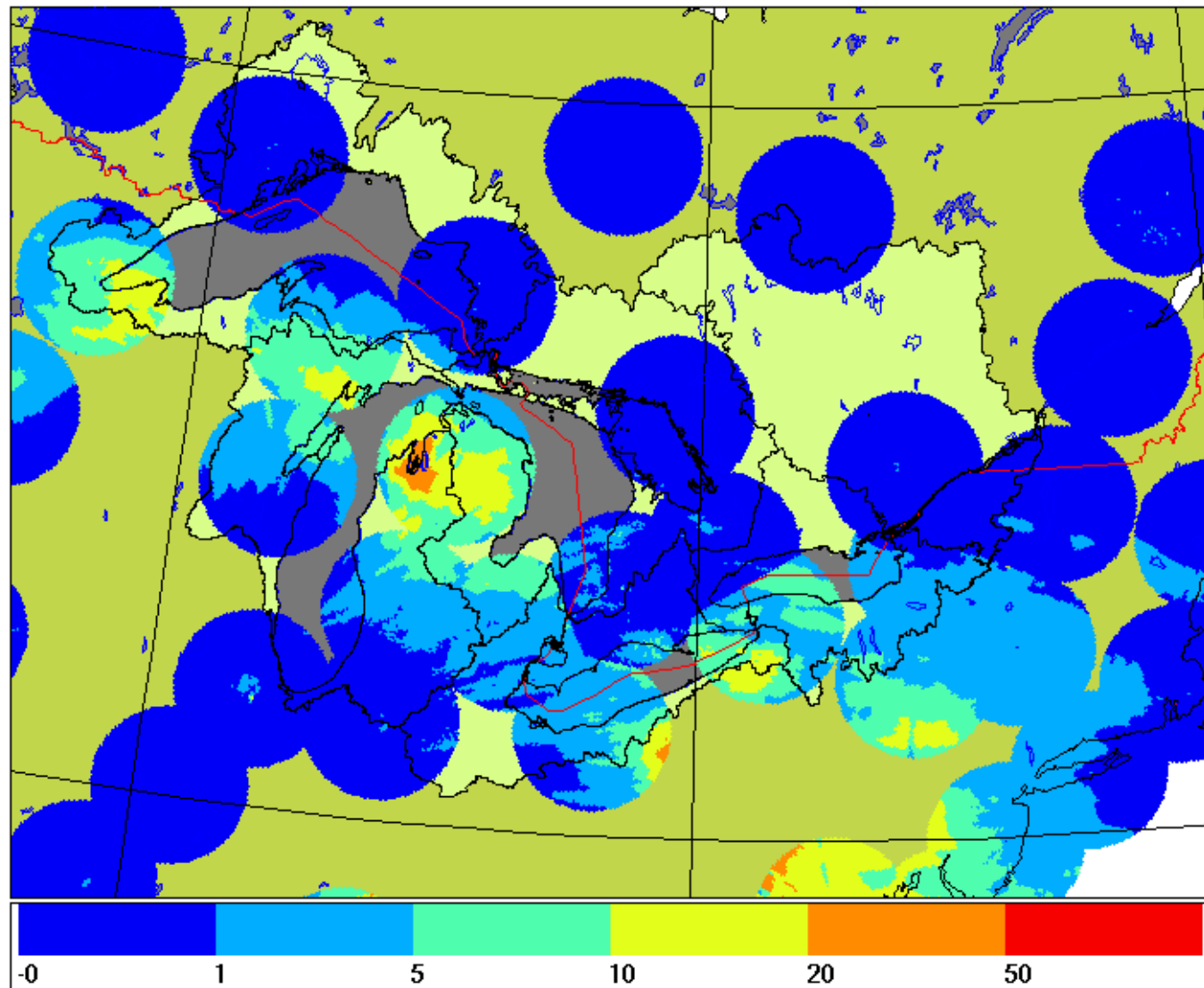
Fall

Winter

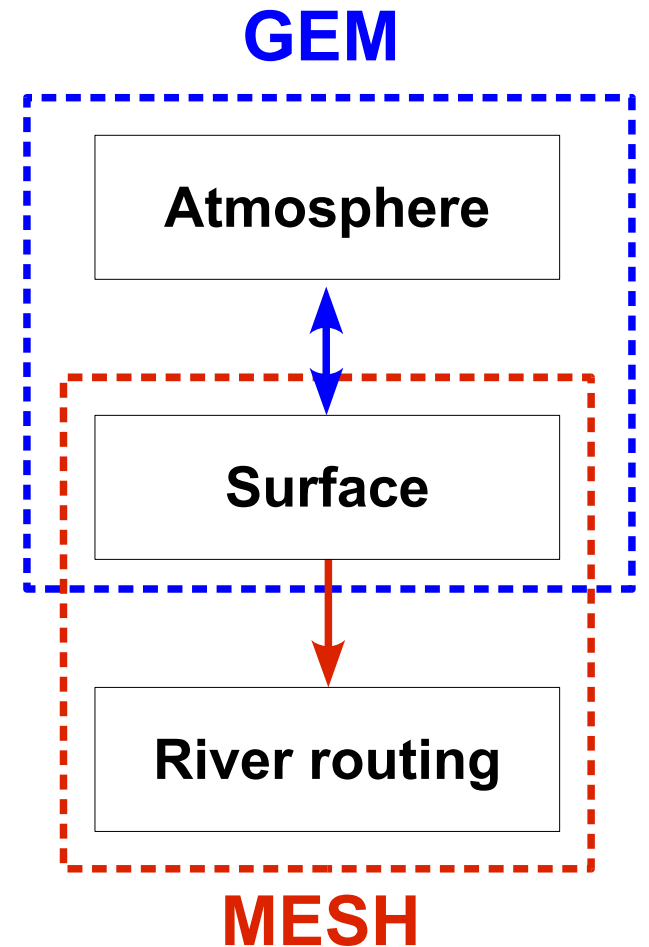
Average daily precipitation Stage IV MPE 2002-2007



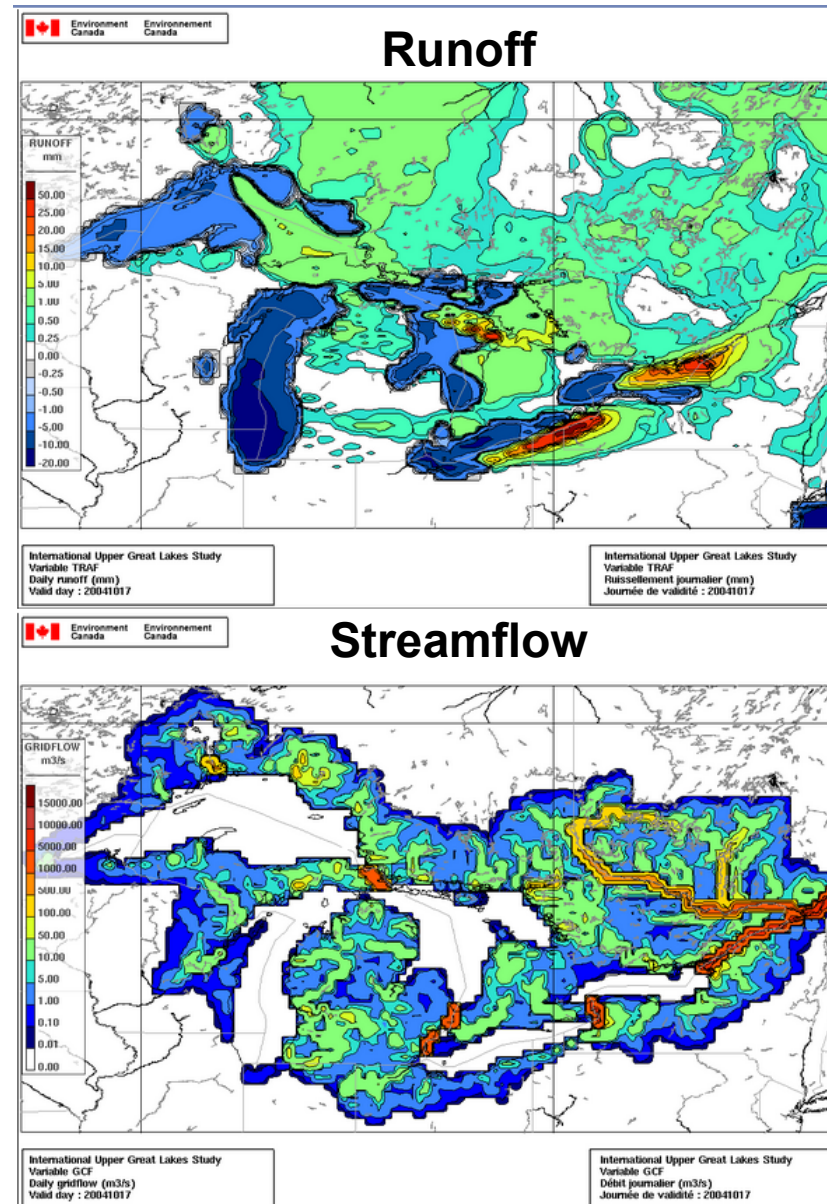
Radar mosaic for the Great Lakes 120 km radius, 2012-02-29 12Z-18Z



Hydrological prediction of Net Basin Supply to the Great Lakes



Horizontal resolution: 15 km



Environnement
Canada

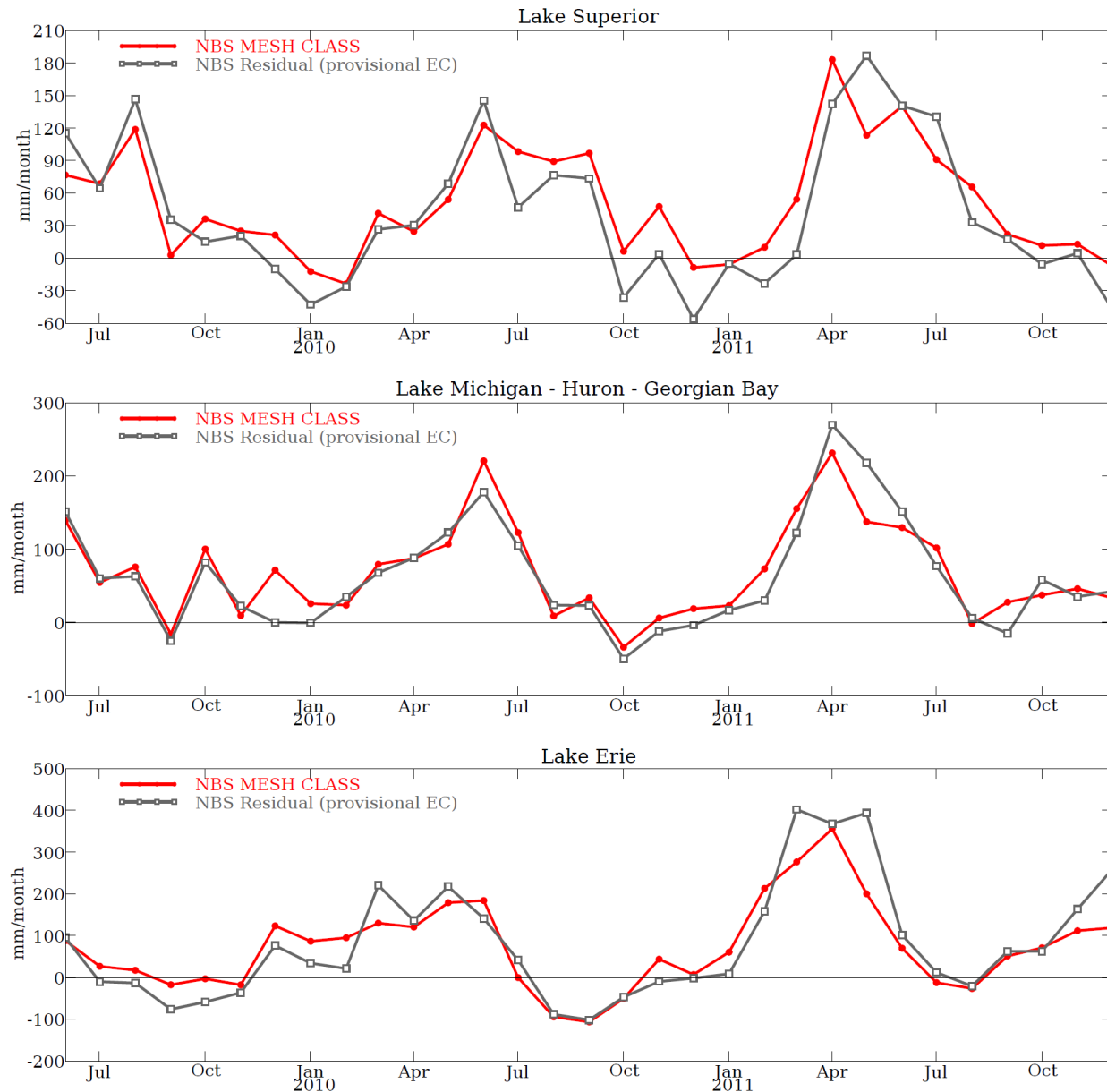
Environment
Canada

Canada

Hydrological prediction of Net Basin Supply to the Great Lakes using GEM

MESH model

- CLASS land-surface scheme
- WATROUTE routing model
- GEM RDPS forcing, 6h-12h lead time



03/15/12



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